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WIRELESS TELEGRAPHY EXPERIMENTS AT THE EIFFEL TOWER.

By Emile Guarini.

On the occasion of a recent trip to Paris, I was seized with the desire of again contemplating, cursively, an old acquaintance, that majestic tower which derives its name from that of its builder, engineer Eiffel, who is known throughout the world from this achievement, which is already aged. But the term aged which I have just applied to this structure must not be taken too literally, since the tower still rises so straight and staunch above Paris that one asks how it was ever possible to say that it had begun to lean and bend.

I observed that some very interesting experiments were yet in progress here under the direction of M. Eiffel, who, having now retired from business, is able to devote himself entirely to them. Thus, the apparatus for the measurement of the resistance of the air is still installed on the tower, and the experiments only await M. Eiffel's return for their resumption on a larger scale. At the present time the most interesting experiments in progress here are those in wireless telegraphy that are being made by Capts. Ferrié and Becq, of the engineer corps, whose most recent achievement was a radio-telegraphic communication, with captive balloons, between Paris and Belfort, a distance inland of 298 miles. This is a record that has never been beaten. Some experiments in wireless telegraphy were made at the tower at the time of the meeting of the Astronomical Society of France last June. These were not only of scientific, but of strategetic importance, and well showed the services that the tower is capable of rendering in this line, not to speak of the numerous ones which it has already rendered and which are not limited to the opportunity that it has given and is giving us to gaze, from an otherwise inaccessible height, at the magnificent panorama that spreads out for almost 65 miles round about.

This is not the first time, however, that the tower has served for experiments in wireless telegraphy. Only three years ago Ducretet performed some with a view to establishing a communication with the Pantheon. At present, the experiments are being made with more method and upon a larger scale. On the other hand, while in Ducretet's experiments

FIG. 4.—THE EIFFEL TOWER WIRELESS TELEGRAPH STATION.

FIG. 1.—THE CONNECTING POINT OF THE ANTENNA.

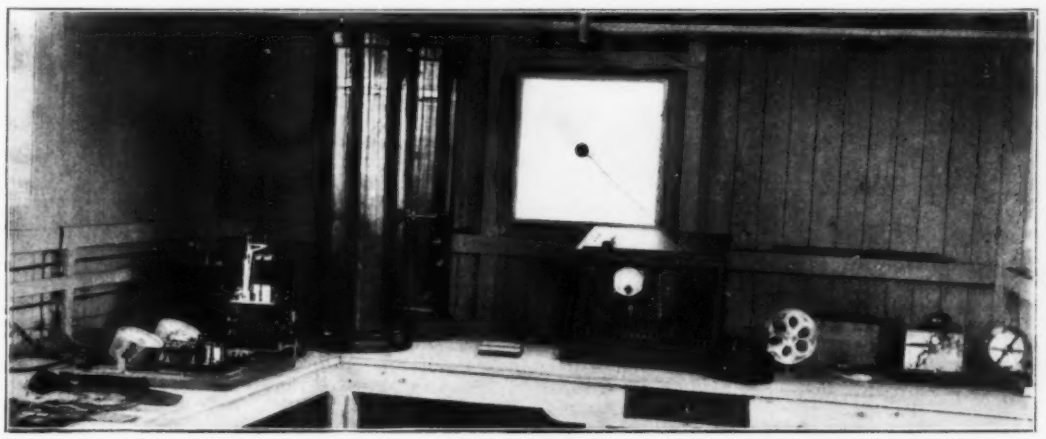


FIG. 3.—INTERIOR OF THE STATION.

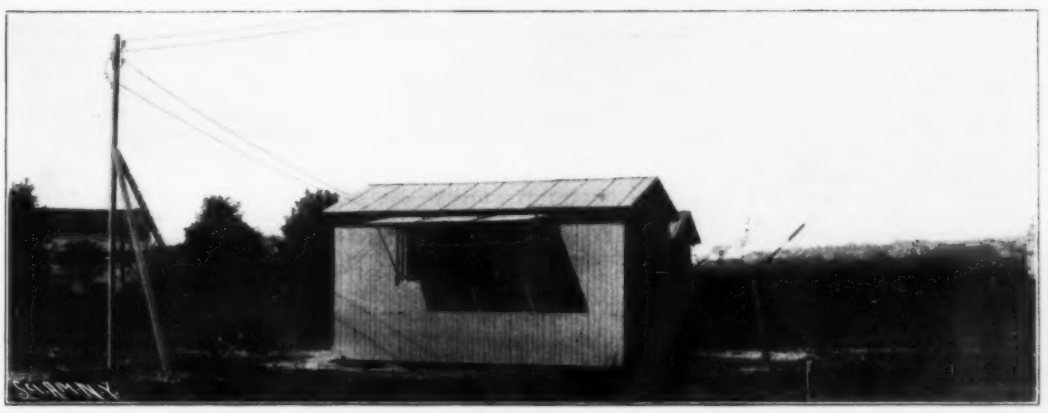


FIG. 2.—THE EIFFEL TOWER WIRELESS TELEGRAPH STATION.

WIRELESS TELEGRAPHY EXPERIMENTS AT THE EIFFEL TOWER.

the tower, on account of its metallic mass, was capable of being used only for receiving. Capt. Ferrié has now succeeded, by means of some new arrangements, in employing it for transmission as well.

The tower station serves not only for experiments in wireless telegraphy properly so called, but also for the study of various other subjects, such as atmospheric electricity, telluric currents, the influence exerted upon the antenna in transmitting and receiving by so great a mass as the Eiffel tower, etc.

For atmospheric electricity, there are facilities to be had that could not otherwise be obtained, not even with captive balloons, since at this great elevation there is afforded an antenna of which it is possible to vary the surface, the capacity, and the height without the least difficulty. There are exceptionally favorable conditions also for the study of telluric currents, since it is evident that a huge lightning rod like the Eiffel tower must produce in the earth certain electric effects of an intensity not common elsewhere.

As for wireless telegraphy, experiments are now taking place with various points of the city, and especially with the Sorbonne, with the forts that surround the city, and with various localities round about. But from what I saw and heard, it seems that the object aimed at is a communication with the ships in the North Sea and the Mediterranean, which is something that from a strategetic, military, and naval point of view, would be of considerable importance for the national defense. The antenna, of a height of 984 feet, is suspended from a pole fixed upon the uppermost floor of the tower. The method of attachment and suspension may be seen from one of the accompanying illustrations. The antenna descends obliquely at an angle of about 45 degrees and ends at a wooden structure located near the tower and constituting the station. This latter is guarded by two soldiers and a sergeant of the engineer corps. The pole that supports the antenna, and the obliquity of the latter, are sufficient to leave between the antenna and the tower a space such that troubles in the transmission shall be completely abolished or at least diminished to the greatest degree possible. For transmitting, there is employed either the direct method in which the oscillator is connected on the one hand with the antenna and on the other with the earth, or the Braun-Marconi inductive method and variants of other inventors and of Capt. Ferrié himself. For the present, use is being made in the transmitters of the Rochefort unipolar coils, which, in Capt. Ferrié's opinion, are very efficacious for wireless telegraphy. For the experiments that are in preparation, powerful industrial transformers are ready for installation. The condenser employed in the transmission, when the inductive method is used, is very interesting on account of its simplicity and its small size. It consists of a grooved box analogous to that employed for the drying of photographic negatives. In the grooves there slide a certain number of thick plates of glass to the center of which are glued sheets of tin foil. The capacity of the condenser can thus be very easily varied at the receiving station.

As for the reception, numerous arrangements are under trial with or without jigger. The Ferrié jigger is very interesting, and differs from all existing types, that is to say, either from the Rochefort, Slaby, etc. (shunt type) or the Marconi, Braun, etc. (induction system). Capt. Ferrié has endeavored to combine the advantages of both processes in his jigger, and appears to have completely succeeded. The Ferrié jigger is constructed as follows. One of the extremities of the coherer is submitted to a tension obtained by a circuit derived from the antenna, and the other to a tension of contrary polarity obtained by induction from another properly selected circuit. Capt. Ferrié very easily varies the sensitiveness of his coherer (usually with a spare chamber of gold filings) by making use of a potentiometer for applying to the terminals of the coherer a more or less elevated difference of potential, which varies from 0.1 of a volt to 1 volt. Things are so arranged that so long as the box containing the apparatus is open, the primary circuit of the coil of the transmitter is interrupted. The necessary current is furnished by the Eiffel tower plant, which generates the continuous and alternating current utilized for the different applications of the structure. When the continuous current is employed, the interruptions in the primary of the induction coil are produced by a mercury motor interrupter. The alternating current will be especially employed in the experiments in telegraphy to great distances, in which industrial transformers will be utilized. Every facility will then be had, since it will be possible to obtain the alternating current in the station itself and to do so without converters.

I asked Capt. Ferrié whether he had tried to utilize the tower as an antenna, a matter which appears to be easy, seeing that the foundation rests upon concrete. He answered that the tower was well grounded by water and gas mains and by lightning rods, and that he expected to eventually be able to make some experiments in this direction. It is unnecessary to say that such experiments will be of the greatest importance from a scientific, technical, and industrial point of view, and the more so in that they will be made by so ingenious and so skillful an investigator as Capt. Ferrié.

Another question that I asked was whether he thought that he could easily communicate with the Marconi station at Poldhu. He, as well as Capt. Becq, answered that there was no doubt about it, and that it will be possible to effect such a communication whenever it may be desired. In support of their assertion, they stated that, on several occasions, signals coming from Poldhu had been received upon the French coast, at Paris, and even at Belfort, which is situated 298 miles beyond Paris, although no preparations had been made for their reception. These gentlemen did not say so, but I think that I have heard that the opposition will come from Marconi, first, because he, as is well known, does not like to have others capable of making long-distance experiments and, second, because his relations with Capt. Ferrié, which were formerly very cordial, seem to be now somewhat strained, doubtless because the Captain has the habit of saying what he thinks about things concerning wireless telegraphy, while Marconi, on his part, has the unfortunate characteristic of believing himself to be beyond discussion.

At the time of the experiments which I witnessed upon a warm day in June, between three and four o'clock in the afternoon, great disturbances were perceived in the communication according as the receiver was very sensitive or but slightly so, and as the jigger was or was not employed. These disturbances were caused by atmospheric or telluric electricity, or by Paris or foreign stations, especially those of Marconi. At times, the signals received had the appearance of letters, but others were constantly received that were undecipherable, despite the efforts made with the jigger to modify or prevent the resonance. These disturbances persisted when either the ground or the antenna was removed, which would seem to show that they were due not only to the atmosphere, but also to the earth, at least to a variable degree. This explains pretty well the negative results obtained at Congo, Belgium, where it was found impossible to establish radiographic communications a slight distance at sea.

In conclusion, I may state that the department of the French marine has just adopted the Ferrié apparatus, and that Capts. Ferrié and Becq, with an arrangement that I hope soon to describe, have succeeded in communicating to a distance of 12 miles, on a level, with quite a moderate energy and almost without antenna. If the system is verified for great distances, it is certain that the experimenters will have satisfied one of the numerous and very important desiderata that wireless telegraphy is yet to furnish.

OUR MYRIADS OF TELEPHONES AND TELEGRAPHS.

THE Bureau of the Census has just published the fourth of a series of reports on the generation and utilization of electric current during the year ending December 31, 1902. The present bulletin concerns telephones and telegraphs, the subjects of the three preceding it being street and electric railways, electric light and power plants, and municipal electric fire-alarm and police-patrol systems. All of these reports were prepared under the direction of Mr. W. M. Steuart, chief statistician for manufactures.

Statistics are shown separately for three classes of telephone systems, as follows:

1. Commercial systems, including all systems operated by individuals, firms, or corporations primarily for revenue.

2. Mutual systems, including all systems operated through a mutual arrangement between the persons deriving benefit from the service, primarily for the benefit of the owners, revenue being incidental to the operation of the line.

3. Independent farmer or rural lines having no regular exchange or central; these lines are often operated under conditions similar to those controlling mutual systems.

Mutual systems are frequently the outgrowth of farmer lines, and commercial systems are frequently developed from mutual systems.

Telegraph systems are divided into two general classes, as follows:

1. Commercial land telegraph and ocean cable systems, including all systems organized primarily for the transmission of messages for the general public.

2. Railway telegraphs, including all wires owned and operated in connection with a railway system, to subserve its business of a common carrier, or operated by a commercial telegraph company through an arrangement with the railway company along whose right of way the wires are strung, whereby messages relating to the railway business are given preference.

Although the commercial telephone has developed entirely during the past thirty years, the bulletin shows that it is now of vastly greater importance than the telegraph. The extension of the long-distance service, the introduction of the commercial systems into rural districts, the establishment of independent rural lines, the development of such lines, in some instances, into mutual systems with an exchange and more extensive service, and the rapidly increasing use of the telephone in private dwellings, all point to a growth of the industry that can hardly be realized. In 1902 the wire mileage operated by commercial and mutual telephone systems together constituted 70.6 per cent of the combined mileage for such systems and commercial telegraph systems, and these same telephone systems gave employment to 70.7 per cent of the wage-earners, paid 65.5 per cent of the wages, received 68 per cent of the revenue, and paid 67.8 per cent of the expenses.

At the census of 1880 the telephone industry was in embryo, few commercial companies being in operation prior to that year. The financial interests represented were relatively of great importance, but the amounts were comparatively insignificant as compared with the totals for 1902.

The number of miles of wire in use in 1902 was 141 times, and the number of telephones nearly 43 times, as great as in 1880. The number of miles of wire and the number of instruments operated in 1902 by the independent rural lines, which in 1880 were not in existence, were in excess of the totals for the entire industry in the earlier year.

In 1880 the population of the United States was 50,155,783 and the number of telephones of all kinds was 54,319, giving an average of 923 persons per telephone; the population of continental United States in 1902 is estimated at 78,576,436, and the number of telephones operated in that year was 2,315,297, giving an average of 34 persons per telephone.

Although in some States the mutual systems and the independent farmer or rural lines are of great importance, the proportion of the telephone business transacted by such systems in continental United States in 1902 was very small. The commercial systems numbered 3,157—three times as many as the mutual systems, of which there were 994—and reported nearly all of the wire mileage, telephones, and subscribers.

The total revenue of all telephone systems, from operation and all other sources, amounted to $86,825,536, or an average of $37.50 per telephone; of this amount, 94 per cent was derived from actual operation. The total operating expenses amounted to $56,867,062, or $24.56 per telephone; the total net income was $21,660,765, or $9.36 per telephone; and the net surplus for the year was $6,678,046, or $2.88 per telephone.

The strong tendency toward concentration is shown by the fact that although only 194 telephone systems, or 4.7 per cent of the total number of commercial and mutual systems, operated 1,000 telephones or over, these systems reported 72.5 per cent of the telephones, 87.5 per cent of the gross receipts from operation, 89.3 per cent of the operating expenses, and 57.5 per cent of the net surplus.

Of the 4,850,486 miles of wire reported by commercial and mutual systems in 1902, 48.9 per cent was overhead, 34.8 per cent underground, and the remaining 16.3 per cent represented circuit miles of wire in overhead and submarine cables.

The commercial and mutual systems reported 2,315,297 telephones as in operation during 1902. Of these, 10,361 were public exchanges, 80,870 were public or semipublic stations or telephones used by the general public upon payment of a stated fee, and 2,224,066 were private telephones.

There were 2,178,336 subscribers reported, giving an average of approximately one telephone to each subscriber.

The estimated number of messages or talks during the year over the wires of the commercial and mutual systems was 5,070,554,553; for the 4,985 independent farmer or rural lines no estimates could be obtained. Of the total number of messages reported, 97.6 per cent were local, and the remaining 2.4 per cent were long-distance and toll.

The commercial telegraph messages sent during 1902 numbered 90,834,789, or less than one fifty-sixth of the telephone messages, and the pieces of first-class mail matter that passed through the mails during the same year numbered 4,611,271,580 or not quite as many as the telephone messages.

Estimating the population of continental United States in 1902 as 78,576,436, there were 34 persons per telephone and 65 messages per person, as compared with an average of 2,190 messages per telephone during the year.

While there has been a wide extension of the telephone service in the rural districts, the industry naturally shows the greatest development in the States having the greatest population, and is carried on to the greatest extent in large cities. Of the 1,051 incorporated places in the United States having a population of 4,000 or over, 1,002 are provided with telephone facilities.

Considering the statistics by main geographic divisions, it is found that the North Central division, which ranks first in population, holds the first place also in the number of commercial and mutual systems, miles of wire, telephones, messages during the year, revenue, expenses, and net surplus. Similarly, the States holding the first six places in rank for each of these items are all among the ten which were most populous in 1900—New York, Pennsylvania, Illinois, Ohio, Missouri, Texas, Massachusetts, Indiana, Michigan, and Iowa, in the order named. Moreover, every one of these States appears in at least one list with the exception of Michigan, which ranked seventh in number of messages. Iowa ranked first in number of systems; New York first in miles of wire, number of telephones, revenue, and expenses; and Ohio first in number of messages and net surplus for the year.

The returns for the American Telephone and Telegraph Company include the data for forty-three licensee companies in whose financial transactions it has a material interest, in many cases owning a proportion of the capital stock sufficient to assure absolute control. The systems operated independently numbered 4,107—3,113 commercial systems and all of the 994 mutual systems. The relative importance of the American Telephone and Telegraph Company's systems is shown by the fact that they reported 69.8 per cent of the wire mileage, 56.9 per cent of the telephones, and 60.6 per cent of the messages reported by all commercial and mutual systems. The number of messages per telephone averaged 2,334 for the American Telephone and Telegraph Company's systems, and 2,000 for the independent systems.

The American Telephone and Telegraph Company's systems reported a far greater number of pay sta-

tions than did the independent systems, but the latter operated nearly twice as many public exchanges as the former. The average amount of line controlled per exchange was considerably greater for the American Telephone and Telegraph Company's systems, being 902.7 miles, as compared with 221.3 miles for the independent systems. The independent systems operated exchanges in all the States and Territories with the exception of the District of Columbia and Utah, and the American Telephone and Telegraph Company's systems operated exchanges in all save Indian Territory. There were twenty States and Territories in which the exchanges controlled by the American Telephone and Telegraph Company's systems predominated, forming 76.2 per cent of all exchanges operated in these States and Territories.

It is impossible to make an exact segregation of the statistics so as to show the number of lines, the wire mileage, and the number of telephones devoted primarily to telephone work in the country as distinct from the urban districts. Approximately, however, there were 21,577 such lines, of which 72.3 per cent were owned and operated by commercial systems, 4.6 per cent were the mutual systems, and the remaining 23.1 per cent were independent farmer or rural lines. The total length of wire was 259,306 miles, or an average length of about 12 miles per line. The total number of telephones was 266,968, giving an average of about twelve telephones to each line and a little less than one mile of wire per telephone. Considering the figures by main geographic divisions, it appears that the North Central States again held first rank. Of the several States, however, New York and Pennsylvania were no longer high in rank, the first five places being divided among the States of Ohio, Indiana, Illinois, Iowa, and Missouri, all in the North Central division. Illinois ranked first in number of rural lines and wire mileage, and Iowa first in number of telephones.

The commercial telegraph systems numbered 25 in 1902, as compared with 77 in 1880. This striking decrease is due, however, to the number of consolidations which have taken place, the magnitude of the equipment and business showing a great increase. At the present time the telegraph business is practically controlled by two companies, yet the number of miles of wire in operation in 1902 was more than four times, the number of messages almost three times, and the receipts from messages more than twice as great as in 1880. The average rate per message in 1902, after deducting the number of cable messages and the receipts therefrom, was 31 cents, as compared with 43 cents in 1880.

The total receipts of the commercial telegraph companies in 1902 amounted to 40,930,038, of which 86.2 per cent represented the gross receipts from operation. The operating expenses amounted to $26,592,411, the net income to $9,982,004, and the net surplus for the year to $3,725,311.

The commercial telegraph companies reported 1,318,350 miles of wire in operation in 1902, but also made a report of 1,307,046 miles as owned or leased. Of the latter mileage, 62.5 per cent was operated by the single or Morse system, 14.1 per cent by the duplex system, 22.6 per cent by the quadruplex system, and the remaining eight-tenths of 1 per cent by machine or automatic systems.

The commercial telegraph messages sent during 1902 numbered 91,655,287, of which 820,498 were cable messages.

There were 684 railway companies that reported the operation of telegraph or telephone lines in connection with the transportation business. Along their right of way these companies had 1,127,186 miles of single telegraph and telephone wire, of which they owned 21.5 per cent.

CONTEMPORARY ELECTRICAL SCIENCE.*

DAMPING OF CONDENSER CIRCUITS.—A condenser circuit whose proper wave-length is sufficiently great in comparison with the length of the closing circuit, and whose plates are a sufficiently small distance apart, sends hardly any electric lines of force into the space outside. Therefore, according to Poynting's theorem, it radiates no Hertzian energy, and its damping is solely conditioned by the resistance of the whole circuit, which, if the wire is not too thin, consists practically in the resistance of the spark-gap. P. Drude follows up this consideration, and deduces some rules of great importance to the practice of wireless telegraphy. For every condenser circuit there is a certain length of spark which gives a minimum damping. In the neighborhood of that value the damping does not vary much with the length of the spark-gap, and however much the inductance and capacity may be varied, the damping can be brought to nearly the same value, if the supply of energy from the induction coil is not excessively large or small, and provided the condenser shows no hysteresis or brush discharges. By a careful adherence to these conditions, the author succeeded in reaching the extremely low value of 0.05 for the logarithmic decrement. The length of the spark gap was between 1 millimeter and 2 millimeters, and the ratio C : L had the high value of 17. It was found essential, however, to attach the supply wires as near the spark-gap as possible, as was the uniform practice of Hertz himself. Righi's method of introducing spark-gaps in the supply circuit has to be avoided, at least when the sparks pass in air. An exciting condenser without hysteresis or brush discharges may be obtained by using metal plates in petroleum, and not connecting them by solid insulators. Zinc electrodes preserve the small damping factor for a considerable time, though a decrease of the damping is noticeable after every fresh cleaning. A Tesla coil can only be recommended for very small capacities. The integral effect of the exciting circuit in a resonating circuit increases at first with the sparking distance, and then decreases. It is considerably enhanced by increasing the supply of energy, which increases the partial discharges. The length of gap giving the greatest integral effect lies somewhat below the value which gives the minimum damping. If, therefore, a good resonance is aimed at rather than a far-carrying range, the spark-length must be slightly increased. If the energy supplied is small, the two critical spark-lengths are sensibly identical. The integral effect depends much more upon the spark-length than does the logarithmic decrement. That in wireless telegraphy much larger spark-lengths have been hitherto employed than those given by the author is due to the employment of the coherer, which reacts, not upon the integral effect, but upon the maximum amplitude. The author would not exceed 5 millimeters even with a capacity of 36,000 and a strong supply.—P. Drude, Annalen der Physik, No. 14, 1904.

NEW PHOTOGRAPHIC METHOD FOR N-RAYS.—H. Bordier has devised a method of registering N-rays which is not open to the objections urged against the spark method, and at the same time gets rid of the difficulties attending the ocular observation of the effect upon a fluorescent screen. The author uses a calcium sulphide screen, but instead of observing the increase of luminosity under the action of N-rays direct, he records it photographically by a prolonged exposure. On a thick piece of paper he drops two groups of collodion drops containing a little of the sulphide in suspension. These are allowed to dry and are kept in the dark over night. The paper is then exposed for five or ten minutes to dull daylight, and is then placed, with the drops underneath, on a photographic plate enveloped in tissue paper. It is left in the dark for 24 hours, a source of N-rays, such as a file, being placed over one group of patches, and a piece of lead of the same weight and the same outline being placed over the other group. After this prolonged exposure the plate is developed. It shows a number of black patches corresponding to the drops, each surrounded by a halo. But in every case the halo surrounding the patches covered by the file is larger than that surrounding the patches covered by the lead. In another experiment, a cardboard box containing pieces of tempered steel was substituted for the file, and another box containing an equal weight of lead was substituted for the lead block. Exposure was made as before, and the plates were sent to the director of the photographic laboratory of Lyon University for measurement. His measurement showed that the patches produced under the steel had a diameter of 6.4 millimeters and a halo 11.7 millimeters in diameter. The other patches had an average diameter of 7.1 millimeters and a halo of 10.8 millimeters. Therefore the patches exposed to the N-rays, although having a photographic image of smaller diameter, produced a wider halo. The author describes a further experiment, which is even more conclusive. A line of sulphide is traced on paper with a capillary tube containing the emulsion. After drying, the line is cut in two, and the halves are exposed to lead and tempered steel, as above. On developing, the image from the steel appears first, and its edge is shaded by a wider halo.—H. Bordier, Comptes Rendus, December 5, 1904.

* Compiled by E. E. Fournier d'Albe in the Electrician.

PRACTICAL DATA ON EUROPEAN PRACTICE WITH STEAM TURBINES.*

By FRANZ KOESTER.

THE remarkable development of the steam turbine in this country in connection with power plants makes it of interest to discuss European practice, which has covered a period beginning perhaps ten years before active work was started here. The lowest steam consumption under actual working conditions in Europe is 9.11 pounds per indicated horse-power-hour, although this does not include the power required to operate the condenser outfit, which in this country is usually considered not over 5 per cent. The lowest record for reciprocating engines is 9.41 pounds (including condensers), which is attained both at one of the street railway power plants in Berlin and in Vienna.

Although there are some half-dozen different types of turbine in use on the continent, the Brown-Boveri-Parsons is the most popular, being installed in some 150 plants throughout Europe.

The rapid increase in the use of the turbine during the past five years was due very largely to the successful operation of the municipal plant in Elberfeld, Germany, for running the suspended railway between Elberfeld and Barmen. Here they have two 1,000 kilowatt Parsons turbines, which operated even at the early date of their installation with a minimum steam consumption of 12.3 pounds per indicated horse-power per hour for one, and 12.1 pounds for the other.

The steam turbine, like the reciprocating engine, may be run both condensing and with free exhaust, and the jet condenser, the surface condenser, the siphon condenser, or a central condensation system may be employed. As there is no oil used in the steam chambers of the turbine, the water from the condenser may be used directly for boiler feed or for other purposes, and it is not necessary to filter it and thus lose a large portion of its heat. The absence of oil in the condensed steam is of special advantage when surface condensers are used, as in this case the cooling water does not mingle with the condensed steam, and the feed water returned to the boilers is thus always pure and free from sediment. It is for this reason that surface condensers are specially appropriate for turbine plants. Quite contrary to the practice in this country, most of the condensers and pumps in these plants in Europe are driven by electric motors.

A turbine lends itself much more readily to the advantageous use of superheated steam than a reciprocating engine, on account of the absence of pistons, stuffing boxes, and cylinder lubrication. As the economy due to superheated steam increases directly with the temperature, the turbine presents another advantage, because there is practically no limit to the superheat it can stand.

The steam consumption of the Parsons turbine, used on the continent, as already shown, will compare favorably with that of the best compound engine built today. The accompanying table gives some data regarding the steam consumption of Parsons turbines furnished by Brown, Boveri & Co., of Baden, Switzerland, and installed in a number of different plants. All the turbines are run condensing and the steam consumption given in the table includes that required for the auxiliaries, except those cases marked *, where this

TABLE SHOWING PERFORMANCES OF BROWN-BOVERI-PARSONS TURBINES, DIRECT-CONNECTED TO C. E. L. BROWN ELECTRIC GENERATORS.

Location of Plant.	Output, Kw.	Output, H. P.	Lbs. Steam pressure, absolute.	Temp. steam, degs. Fahr.	Steam, lbs. per I. H. P. hour.
Refrigerating plant, Berlin*	100	135	129	352	15.6
Electric plant, Chur	200	267	184	442	13.6
French navy yard*	280	420	216	+	13 8
Nord-Deutcher Lloyd, Bremen	300	400	147	+	14.0
Street railway, Linz, Switzerland	300	400	182	+	14 2
Cellulose factory, Villach	350	467	169	482	12 1
Rolling mill, Antonienhütte*	400	533	110	+	13 0
Shipyard, Kiel*	400	533	132	+	13 0
Spinning mill, Colmar*	404	538	162	445	11 7
Mine and pottery, Tschopein	400	533	110	406	13.0
Iron and steel works, Diedenhofen	470	600	118	482	11 8
Iron and steel works, Hösch*	500	667	110	452	12 5
Schlieper and Baum, Elberfeld	500	667	147	482	11 6
Municipal plant, Frankfort*	3,000	4,000	162	572	9 11

* Steam for power to operate condenser not included.
† Saturated.

work is not included. The table shows clearly the decrease in steam consumption as the size of the turbine and degree of superheat increase, and from the data here given it may safely be expected that in the 10,000-horse-power turbine, which is at present being constructed by Brown, Boveri & Co., the steam consumption will be considerably less than 9 pounds per indicated horse-power per hour.

In comparing the results of the turbine tests with those of reciprocating engines it must be borne in mind that it is usual to make special preparations before testing reciprocating engines, while there being no parts of the turbine subject to excessive wear, there is no necessity for special preparation at the time of test; indeed, tests made several years apart will show the same results.

As an example of the stability and slight wear of the turbine, it may be interesting to refer to the 500-horse-power Brown-Boveri-Parsons turbine in the Carlshuette at Diedenhofen, Germany, which was in service 5,800 hours continuously, except for a single stop of ten minutes' duration. At the end of the run the turbine was taken apart by the company's engineers and examined carefully for evidence of wear, of which not the slightest could be found.

In comparing performances of reciprocating engines with those of turbines, it is necessary, not only to take into consideration the steam consumption of the engine and turbine, but also to consider the wear and tear on the engine and the oil required.

The Bavarian Inspection Society thoroughly investigated this subject of oil and found that in compound and triplex expansion engines of 100 to 1,500 horse-power the oil consumption was about 2 grammes per horse-power-hour, costing 1-40 cent. In the Parsons turbine the oil consumption is practically negligible as compared with reciprocating engines, the figures being 0.1 to 0.3 gramme per horse-power hour in units of 100 to 1,500 horse-power. With the reciprocating engine the cost of the oil consumed amounts to 7 to 15 per cent of the cost of the coal used, while with the Parsons turbine the cost of the oil ranges from ½ of 1 per cent to 2 per cent of the cost of the coal.

The attendant delay due to the preparation of an additional reciprocating unit for service is entirely avoided with the turbine, for it is equipped with a by-pass valve by means of which steam at full pressure may be admitted to the second or low-pressure steam chamber; and the capacity of the turbine is thus largely increased. This by-pass is also of great advantage in case of an accident to the condensing apparatus which would necessarily decrease the power of the turbine, just as it would in the case of an engine. The use of this by-pass, however, means a less economical steam consumption.

* Engineering Record.

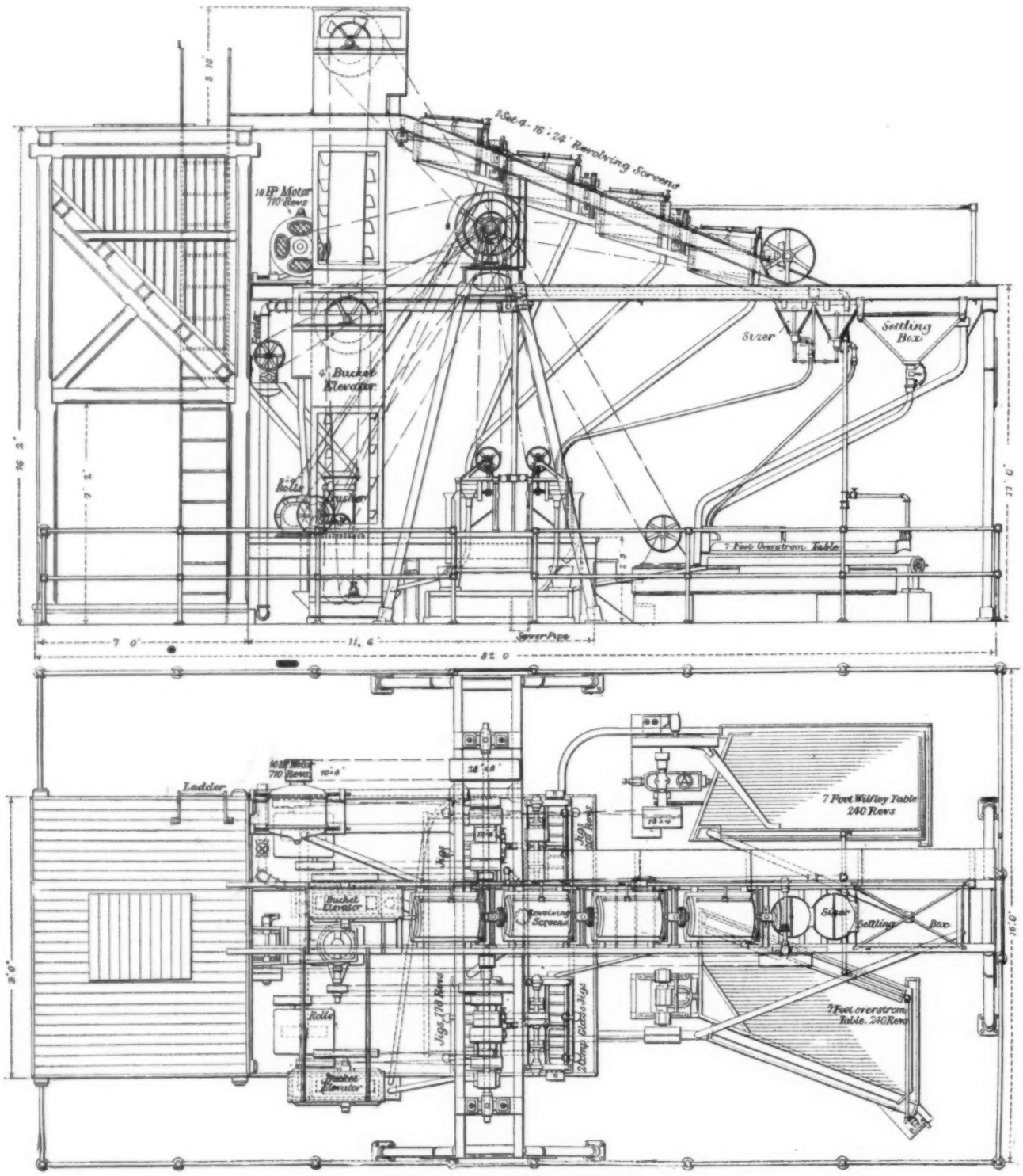
ORE-CONCENTRATION PLANT AT THE ST. LOUIS EXHIBITION.

THERE was exhibited in the Mines and Minerals Building at the St. Louis Exhibition a large-size working model of an ore-concentration plant which had been especially designed for the use of a mining company operating in the State of Utah.

The ore is first placed in a storage-bin, and from here it is discharged to the crusher, there being a feeding device to facilitate the passage of the ore. The crusher is of the standard Gates gyratory type, which is set to reduce the ore to a size of about ⅜ inch. From here the material drops into a vertical elevator, the buckets of which may be seen in the upper illustration, and is discharged in a set of four revolving screens arranged on a slope, as shown. These screens have steel coverings with gear wheels for driving them. The first screen has ⅜-inch openings, the second 3-16-inch openings, the third has ¼-inch mesh, and the fourth 16 mesh. The products from these screens are disposed as follows: The over-sized ore from the first screen is returned to a set of crushing rolls, shown to the left of the illustration, and from them the crushed ore is again passed to the bucket elevator, and from thence to the screens. The under-sized ore from the first screen—that is to say, that which is below ⅜ inch—passes to the 3-16 inch screen. The over-size from the latter screen is passed to a two-compartment jig, shown in the center of the lower part of the apparatus. The under-size passes to the 8-mesh screen, and the over-size of the latter is also treated in a two-compartment jig, the under-size passing to the 16-mesh screen. The over-size from the latter is treated in a two-compartment jig, while the under-size passes to an hydraulic sizer, the bottom product of which is treated upon a two-compartment jig. The overflow from this sizer passes to a second hydraulic sizer, and the bottom product of the latter is taken to an Overstrom concentration table, which has an iron frame and copper riffles. The over-size from the second hydraulic sizer passes to the settling box, the product of which is treated upon a concentration table. The over-size from the settling box will contain no mineral, and is allowed to run to waste.

The middlings and tailings from the first and second two-compartment jigs will probably contain some mineral. They are therefore re-crushed in a second set of rolls, after which they are carried to the screens by means of the elevator. The concentrates from the different jigs and from the concentration tables are collected in boxes beneath the jig floor.

The model was well devised for illustrating the action of the plant, glass being largely used in the construction, so that the passage of the ore might be seen. In regard to the different elements of the plant it may be said that the Gates gyratory crusher is well known, and the rolls used are of the type largely employed in the crushing mills of the West. The revolving screens are modeled upon the type in use in western concentration mills, and the jigs have been constructed after the Hartz pattern, also well known to the miners of the west country. The hydraulic sizers are of the familiar cone design, and the concentration tables used represent the two leading types of machines for fine concentration.—Engineering.



ORE-CONCENTRATION PLANT.

CONSTRUCTED BY THE ALLIS-CHALMERS COMPANY, ENGINEERS, CHICAGO.

PUMPS.

By PHILIP R. BJÖRLING.

PUMPS as a rule are poor, neglected machines. The engines must be polished up and kept clean, but the poor pump must work in dirt and grease, sometimes to that degree that you can hardly, at first glance, discover what it is, and the attendant is surprised that it does not work well, and that it gives a good deal of trouble.

A great evil with pumps is also the careless manner in which they are designed; anything that will deliver water is good enough—a cylinder with some valves will do. In the writer's younger days his employers made him design pumps with great faults in them, because they looked more symmetrical, or because the pattern cost 2s. 6d. less, although in many cases it cost 15s. more to mold that pump in the foundry, showing the want of knowledge in the practical part.

In starting to design a pump the first consideration should be perfection in the construction, totally disregarding economy and beauty. When the pump has been thus designed, look it over and try to cheapen the manufacture as much as possible without altering the construction; make it look as nice as is compatible without interfering with the first two elements.

There are different ideas about what a pump really is. Some call any machine for raising water a "pump," but the general accepted definition of the term is "a hydraulic machine for raising water by the aid of atmospheric pressure."

Pumps may be broadly divided into piston pumps, ram or plunger pumps, bucket pumps and centrifugal

pumps. There are many other forms, but as these are only occasionally used, it is not proposed to consider them in the present article.

Piston Pump.—This class of pump is usually made double-acting. It consists of a cylinder, in which a piston reciprocates, having suction and delivery valves at each end. The good qualities of the design shown consist in compactness, freedom from air-lodges, great strength, as nearly all the surfaces are round; but it would have been better, as regards clearance space, if

FIG. 1.

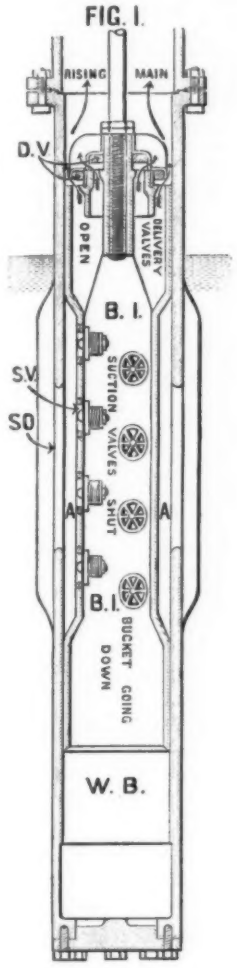


FIG. 2.

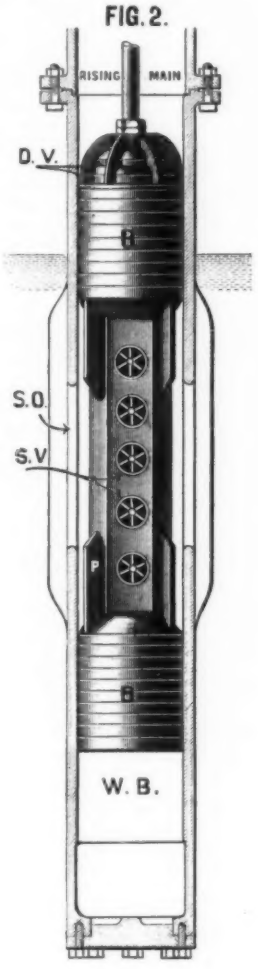
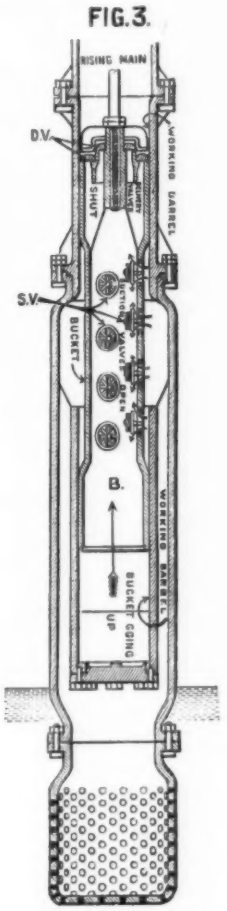


FIG. 3.



the delivery valve boxes had been made independent of each other and connected by a pipe.

The pump rods are usually made of mild steel, but if the water contains acid or saline matter they are made of Muntz metal, gun-metal, phosphor bronze, and Delta metal. Although it is a trifle more expensive we should, in any case, use Delta metal, the author having found it for years to be by far the best, both as regards the tensile strength and wear. Steel is not good because it easily becomes fluted by grit and dust, especially in coal or other mines.

There are many ways in which the piston is secured on the rod, but probably the best plan is the one shown in the diagram, which consists of a nut on each side of the piston; this forms a large shoulder on the rod, and a ready means for adjustment of the length of the rod; it also weakens the rod less than when a shoulder is formed on the rod, as it reduces the screwed part a great deal, or the shoulder becomes so small that the rod will wear itself into the piston, and the latter will work backward and forward on the rod.

The pump piston is fitted with ordinary cup-leathers, between which is placed a gun-metal ring properly turned to the radius of the corner of the leathers. In cases where hot or warm water is pumped the cups may be made of "dermatine," or any other ordinary steam piston packing rings may be employed. The nut behind the piston should be prevented from working loose by a split pin or cotter behind the nut, not through it, so that any slack that may take place can be taken up.

Ram Pumps and Plunger Pumps.—There is a slight misunderstanding about these pumps; the names are used indiscriminately, as if the two were identical. This is, strictly speaking, not the case. The single-acting type is the plunger pump, because it is plunged into the liquid; and the double-acting type is the ram pump, because it moves the water and is always in the liquid it forces.

The plunger pumps are mostly used for heavy work, and where sandy, muddy and gritty water has to be dealt with. For mining purposes there is no better class of pump, especially in the shafts; but they are also excellent for electrically driven pumps, because the load is very evenly distributed in each revolution, three pumps being used and the cranks set at an angle of 120 deg. with one another. A very good example is shown, made by Messrs. E. Scott and Mountain. In this case the plunger is made of gun-metal, although sometimes, but not advisedly, it is made of cast-iron covered with brass or gun-metal; the latter method will do for light pressure, but for heavy pressure the water sometimes finds its way between the liner and the body, and the leaks cannot be easily stopped when they once have commenced.

In many specifications the writer has found it stated that the plunger has to be draw-filed; there could not possibly be anything worse done than that. When draw-filed a continuous number of minute flutes are made round the plunger for the water or other liquid to flow along. The plunger should be finished in the lathe by a fine cut with a slow traverse of a diamond pointed tool; a plunger finished that way will, in a few day's work, receive a beautiful lasting polished surface which no machining or filing can give.

It will be noticed that there is a free current for the air to flow through the pump, and therefore no air lodge. The suction valve seat is kept below the underside of the waterway; this is a very good feature as it allows the water to rise straight up a short distance without having any tendency to draw the valve toward the waterway. If the valve seat and underside of the waterway are on the same level, which is too frequently the case, the valve gets a tilting action, and if there is the least slackness of the valve in its seat, the valve will stick at the top of its lift till the pressure becomes great, when it is released and comes down on its seat with a blow like a hammer. Another excellent feature in this pump is that all the parts are interchangeable, so that fewer duplicate parts are necessary to be kept in store.

Bucket Pumps.—This class is similar to a single-acting piston pump, but has a valve fitted in the piston. It is seldom used except in mines, vertical single-acting air pumps and ordinary hand pumps being employed for country places. It makes the best air pump, because the air rises all the way through the pump, the only obstruction being the bucket and overflow valves.

There are two modern pumps of this class which are worth noticing—(1) the Ashley pump, for waterworks, and (2) the Edwards air pump, for electric-light stations.

(1) The Ashley pump was invented and patented by Mr. Herbert Ashley, late assistant engineer to Mr. W. B. Bryan, chief engineer of the East London Waterworks, and is manufactured by Messrs. Glenfield & Kennedy.

It consists of a bucket (Figs. 1, 2 and 3) which is made very deep, and provided at each end with a piston. The latter can be made plain or provided with packing of any description, as may be found necessary. The part of the bucket between the pistons is made hexagon or octagon, according to the diameter of the pump; in this part are the suction valves, which are placed horizontally, and the India-rubber disks placed vertically, so that if any sand or grit should get be-

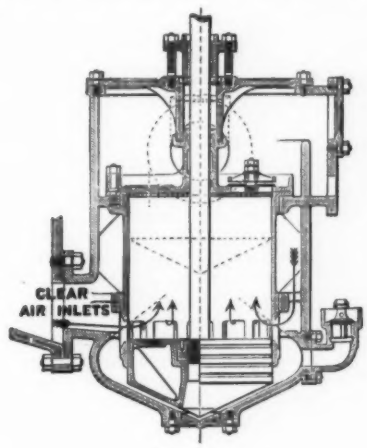


FIG. 4.

tween the grid-seat and the disk, it will directly wash away. The India-rubber disks are fitted on the back with springs, to assist the valves in closing quickly. It will be noticed that the working barrel is provided with slots or inlets from the suction pipe shrouding, the slots being so arranged that the top piston of the bucket, when at the bottom of its stroke, does not cover them, and the bottom piston will be clear of them when at the top of its stroke. The principle of the action of this bucket pump is similar to the ordinary one, except that there is no suction clack or valve of any description under the bucket, all the valves being placed in the bucket. If anything should get out of order with the suction valves, it is only necessary to withdraw the bucket, which has been drawn, and the bucket replaced within half-an-hour between stopping and starting the engine. Every practical man knows how difficult it is to fish a suction valve, when the clack piece is drowned; if you are lucky it may take you a week—the writer has even known it to take months before it was extracted. On account of the large area of the waterway through the valves, the pump can be run at the speed of 200 feet or more per minute. Another great advantage of this pump is that it takes up very little space, and it is therefore recommended for artesian well and bore holes.

(2) The Edwards air pump is shown in Fig. 4. It is one of the best air pumps now manufactured. The lower part of the pump is so constructed that the water passes through the lower part of the ports, the upper portions being left clear for the perfectly free entrance of the air. Neither gravity nor pressure is required to make the water pass into the barrel, and therein lies one of the essential differences between this and other pumps. It will be noticed that there is neither foot nor bucket valves in this pump; the only necessary valve is the overflow. Free air inlets are maintained, and the water, instead of obstructing the entrance of air as is the case in the ordinary type of air

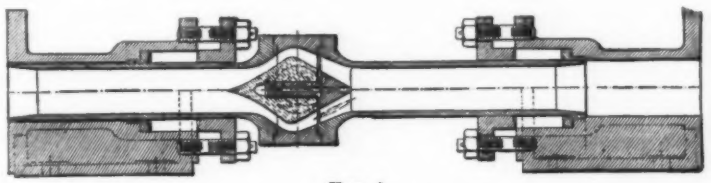


FIG. 5.

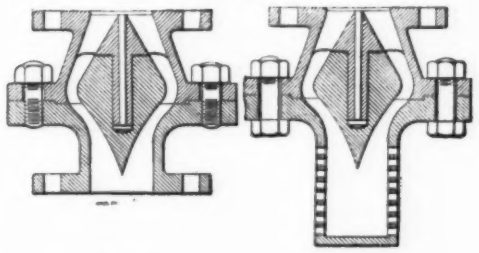


FIG. 6.

FIG. 7.

pump, tends to compress the air already in the barrel, and to entrain or carry in more air with it.

The condensed steam flows continuously by gravity from the condenser into the base of the pump, and is there dealt with mechanically by the conical bucket working with a base of similar shape. Upon the descent of the bucket the water is projected silently and without shock at a high velocity through the ports into the working barrel. The rising water is followed by the rising bucket, which closes the ports, and, sweeping the air and water before it, discharges them through the valves at the top of the barrel.

In this air pump, the speed of the water must correspond to the speed of the bucket, and consequently the pump, having a small and regular quantity of water to deal with at each revolution, is particularly well suited to work at high speeds, such as those commonly adopted for engines of torpedo boat destroyers and other fast vessels.

"Haste Inertia Pump."—We now come to a different pump, which is very difficult to classify. It is a kind of bucket pump and at the same time a ram pump. It is called by the inventor "Haste Inertia Pump," and is illustrated in Figs. 5, 6 and 7. "There is nothing new under the sun," says the old adage; this is again proved by the principle of Haste's pump. It has been patented over and over again, both in England and abroad. As usual in such cases, success depends upon some apparently trivial feature or some small detail, and it is by attention to such that Mr. Haste has overcome the difficulties experienced by others in applying the principle involved in his design. The whole secret lies in the valve contained in the elongated bucket. By this arrangement of valve, although the pump is of the reciprocating type, the plunger can be run at very high speeds, and will therefore give a very great displacement considering its diameter.

This pump, as shown in Fig. 5, consists of a hollow plunger working through two glands and stuffing boxes, one of which is formed in the suction pipe and one in the delivery pipe or rising main. At the center of the length of the ram is fitted a valve made of "dermatine," in such a manner that the beating surface is hard and the top part soft and compressible. The valve is guided on a spindle secured to a crosspiece in the side of the ram, the ribs holding the crosspiece being tapered top and bottom, so as to minimize the friction of the water.

The ram being reciprocated at a high speed by any class of motor, the valve is supposed to close on the upstroke, and impart so high a velocity to the water in the delivery pipe that the inertia of this water maintains a continuous discharge through the down-stroke of the ram, so that in practice the flow of water is continuous, hence no pressure or suction air vessels are required. Although the valve is supposed to close, it does not actually do so, for this pump has a discharge varying from 41.6 to 123 per cent of the theoretical quantity, according to the head against which the pump is working. The waterway past the valve is very free, the area for the passage of the liquid being the same as in the bore of the ram.

Bucket-and-Plunger Pump.—This class of pump is a useful combination of a bucket and a plunger pump. The advantages are single-acting suction and double-acting delivery, so that it has only two valves, one in the bucket and one delivery valve. The plunger is one-half the area of the bucket, hence on the up-stroke the full displacement of the bucket is effective, drawing the water into the working barrel. On the return stroke half the amount of water flows into the delivery pipe, the other half remaining in the barrel till the next up-stroke, when it is lifted up into the delivery pipe.

The piston-and-plunger pump is a pump on similar principle as the last-mentioned pump, but is fitted with a piston instead of a bucket.

Centrifugal Pump.—This class of pump is totally different in its action from those already described. The action of the centrifugal pump is as follows: The pump being charged with water, the impeller or fan is set in motion at a great speed, imparting centrifugal motion to the water contained in the impeller, and so driven into the casing or body of the pump. By the partial vacuum thus created in the impeller the water is forced up the suction pipe by the pressure of the atmosphere; the water entering the disk receives again a centrifugal motion, and by this means a continuous stream is received into and discharged from the pump. This fundamental principle applies to all classes of centrifugal pumps.

The advantages of these pumps are that they deliver a larger body of water, in proportion to space occupied and prime cost, than any other class of pump. They can deal with sandy, gritty, and muddy waters. They are easily fixed, and require very small and inexpensive foundations.

The disadvantage is that they cannot raise water to any great height. Comparing the centrifugal pump with other classes of pumps it may be said that for lifts above 20 feet the results are in favor of reciprocating pumps; that for lifts under 20 feet the two classes are equal, but that for lifts of 4 feet to 5 feet centrifugal pumps have a most decided advantage.

Wing or Flap Pump.—It is a very useful type of small pump, and is used for raising wort in breweries, and for filling and emptying casks for wine, oil, or other liquids. There are many varieties of these pumps, but the simplest and probably the oldest consists of a cylinder, bored true, having a center shaft, on which is fixed a pair of wings or arms. These wings are fitted with one valve on each side. On the outer end of the shaft is fitted a lever, which can be worked by hand, by an engine, or a wind motor. There is a division secured in the bottom of the cylinder by means of bolts, a midfeather reaching to the boss of the wings. This division is fitted with valves.

The action of this pump is as follows: When the lever is moved toward the left, the suction valve will open and fill the right-hand side of the cylinder, and the valve will open and deliver the water or other liquid out of the left-hand side of the cylinder. Now if we move the lever toward the right, the suction valve will open and the left-hand side will be filled, the valve will open and deliver the liquid from the right-hand side. The joints between the cylinder and the wings, also that between the suction valve seat and the boss on the wings, can be made by leather or India-rubber.

Hints on Pumps.—We have now noticed a sufficient number of pumps, because the remaining classes and types are only modifications of the above pumps.

We will now consider the practical parts to be noticed in designing a pump, as well as the points to watch when we buy one.

First of all we must look for air-lodges, which is the most important part in a design, that is we must guard against any place where air, entering into the pump with the liquid, can remain; the pump valves and passages must be so arranged that the air will pass direct through the delivery valve and delivery pipe, or into the air vessel if one is employed. Many have met with cases where vertical double-acting piston pumps have only been delivering from the down-stroke, and may have at first wondered how it was. It is simply because the pump has been designed so that the air cannot escape from the working barrel into the delivery pipe, preventing a vacuum from being formed, the air being alternately compressed and expanded in that part of the pump.

The next important point is clearance space, that is the space between the suction and delivery valves and the piston or plunger, as the case may be. The larger the clearance space the less distance the pump can fetch the water. The writer has often made a pump fetch the water by simply lining the inside of the valve boxes and passages with wood so as to reduce the amount of clearance. The more water there is the more air is contained and hence a less perfect vacuum.

The speed of a pump is a most important matter which has been very little discussed, and various opinions and explanations have been given, and to some minds have been satisfactorily proved. Some engineers favor the idea that the speed of the water can only be equal to a pressure of 15 feet per square inch, but it is not so. The water enters the suction pipe at a velocity equal to that of a body falling from a height of 33 feet per second, so that if we use the ordinary formula for falling bodies,

$$V = \sqrt{2\,g.\,S},$$

in which V = velocity in feet per second, g = gravity = 32.2, S = space traveled through in feet; we get, in this case,

$V = \sqrt{64.4 \times 33}$ = about 46 feet per second, and $46 \times 60 = 2{,}700$ feet per minute, if everything were perfect and there were no friction in the water in the suction pipe, clear water-way through the suction valves, the valves made of large area, all rods, etc., perfectly rigid, and quick reversal of the water; and, if the pump is properly designed, we can use a piston speed of 800 feet per minute, and even 1,000 feet at an emergency.

This speed is constant, as long as the vacuum of the pump is good; it does not depend on the length of the suction pipe or the height of the water level to the top of the pump, that may be 1 foot or 20 feet, if the pump and valves are well designed and in proper order.

With regard to the size of the pump required, many different, and apparently contradictory, rules are used in practice. The rules in the text books give the quantity and the size in different ways, as, for instance, in some the result is gallons per minute, in others gallons per hour; some take the diameter of the pump in inches, and others in feet; on this account the coefficient naturally varies and some engineers will never employ a formula with a coefficient if they do not know how it is obtained.

The most common rule is:

$$G = D \times 0.034 \times F$$

$$D = \sqrt{\frac{G}{0.034 \times F}}$$

in which D = diameter of pump in inches, G = imperial gallons delivered by the pump per minute, F = speed of the bucket, piston or plunger in feet per minute. This is the theoretical quantity.

A very simple and practically near enough rule is—square the diameter of the pump and multiply by twice the piston speed per minute, which gives the number of gallons delivered per hour. For example, a pump 6 inches in diameter, running at a speed of 100 feet per minute, the pump being double-acting. Then we have $6 \times 6 = 36 \times 200 = 7{,}200$ gallons per hour, or if 7,200 gallons and 100 feet piston speed, divide $7{,}200 \div 200 = 36$ and the square root of 36 is 6. According to the theoretical rule it would be $36 \times 0.034 \times 100 = 7{,}344$, so that our approximate rule is on the safe side.

Of course, in both rules something must be allowed for slip in the valves and imperfection of the joints and vacuum. In a well designed, constructed, and properly connected pump this should not be more than 10 per cent, but the writer has met with pumps where not more than 50 per cent of the theoretical quantity could be got.

One of the most important points in the selection of a pump is the liquid to be dealt with. As an illustration of this may be mentioned that on one occasion the writer had a sample of the liquid sent; it contained sugar, and for that purpose it must be made only of gun-metal; it contained some tar, and no gun-metal can be used for tar, it must be cast-iron only; and it contained strong acid, for which purpose lead, antimony, and tin must be employed, as an alloy, but the antimony ruins both sugar and tar, therefore the writer recommended that the pump be made of vulcanite.

For strong acids the pumps are made of earthenware or stoneware of the plunger type; or lead, tin, and antimony suction and delivery chambers and glass barrels, the pump being of the bucket type.

Sometimes the acid is raised by means of double-acting air pumps. The acid is run into cylinders, called acid eggs, by gravity; when the egg is full, the delivery pipe of the air pump is set in connection with it and the pump forces air into the egg, and by that means elevates the acid to the tank or cistern without passing through the pump.

For weak acids, double-acting piston pumps, or plunger pumps, having all parts made of gun-metal.

When tar or ammoniacal liquor has to be raised, brass or gun-metal must not come in contact with the liquid, fluid, or semi-fluid.

For benzole and benzoline, double-acting piston pumps, or single, double, or treble barrel bucket pumps, made of cast-iron, with gun-metal or gun-metal lined working barrels or barrel, should be used.

In bleaching mills the pumps mostly employed are double-acting piston pumps, or treble barrel bucket pumps, of cast-iron, with the barrels of gun-metal or lined with gun-metal.

For sugar solution and treacle, double-acting piston pumps, and single, double, or treble barrel pumps of the plunger type, all parts made of gun-metal. The following alloy is very suitable for sugar and salt water: Copper 88 per cent, zinc 2 per cent, tin 10 per cent.

Brewery pumps for wort are mostly made of the treble barrel bucket type, all parts made of gun-metal. For very small sizes the semi-rotary or wing pump, with all its parts made of gun-metal or brass, is to be recommended.

It is very difficult, in the limited space available in the present article, to discuss the class of pump which should be used for waterworks, as it depends greatly upon circumstances which occur at different places as regards the source of the water, the depth of suction, the position of the reservoir, if any. But if it is clear water, free from sand and grit, piston pumps should be adopted; if sandy and gritty, double-acting plunger or ram pumps; if bore-holes the "Ashley" pump; if the well is shallow "Haste" pump; if deep suction, three-throw or treble-barrel pumps. If driven electrically, treble-barrel pumps of the ram type should be used, as the most regular distribution of power is obtained, therefore most suitable for an electric motor.

In fixing a new pump of any class or type, every care must be taken that all dirt, grit, and sand, iron and brass turnings and borings, are carefully cleaned out of the working barrel, ports, and passages, on account of great mischief having been caused by neglecting this precaution.

The size of pipes specified by the maker should be strictly adhered to, and all packing rings at the joints should have a hole of such a size that when the joint is tightened up it will not interfere with the bore of the pipe.

The bends in the pipes should have no radius, if possible, less than three times the diameter of the pipe.

A dirt box should always be provided, where practicable, as near the pump as possible, and when the suction pipe is long a suction air vessel or, as it is sometimes called, vacuum vessel, should be fixed on the suction pipe, near to the suction branch of the pump.

A back-pressure valve ought to be placed at the bottom of the delivery pipe, to keep the water back when the pump is repaired or examined.

When the suction pipe is deep, it is a good plan to have a pipe fitted with a cock, connecting the delivery pipe with the suction pipe, so that the latter and the working barrel of the pump can be primed before starting the pump.

A pressure or delivery air vessel should be placed at the highest part of the pump, so that the air entering with the water will find its way into it.

The air vessel usually supplied with small pumps is worse than useless. When the pump has been working a few days, especially under heavy pressure, it will be filled with water instead of air.

To the air vessel should be fitted an apparatus for charging it with air so as to give a constant water level in the air vessel. There are two classes of these apparatus; mechanical and automatic. Mechanical arrangements consist of pipes and cocks so arranged that the water can be run off and air admitted, and the automatic is a class of pump which is worked by the liquid in the main pump and automatically keeps a constant supply of air in the vessel. The best automatic air injector the writer knows is the Wipperman & Lewis air charger, manufactured by Messrs. Frank Pearn & Co., Ltd.

Air vessels should always be provided with a glass water-gage, so that the water level can be seen at a glance.

Three-throw pumps are so even in their delivery that it is hardly necessary to provide them with an air vessel.

Great care must be exercised in making all joints perfectly tight, especially those in the suction pipe, both to obtain the very best duty of the pump, as well as for keeping the place clean and dry.

The pump rod packing should be carefully made, and the gland gently and evenly tightened up, because if this is not done, a great amount of extra friction is created; in fact in large pumps the engine can be completely pulled up by undue and uneven tightening of a plunger gland. The writer has seen vertical water-works plunger pumps working well without any packing at all.

Pump rods should always be kept clean, free from dirt and grit, which flutes the rod, and well lubricated. When the water is acidulated the lubrication greatly retards the corrosion caused by the acid.

A frequent examination should be made to see that the valves, their faces and their beat on the back seat are in good order, so that no slip or back-flow of the liquid into the suction pipe takes place.

There is one peculiarity with some India-rubber disks which is very little known, but should be noticed. If one of the faces of the disk be placed toward the grid seat the disk becomes slightly convex on the bottom face and a great amount of liquid slips back into the suction pipe, but if the disk is turned round so that the other face comes on the grid seat, it is all right for work. This fault is increased when the center of the disk is made tight between the guard and the seat.

The pump pistons should be examined, after a new pump or new piston has been working a few days, to see if it is perfectly bedded, and if not, put right. After that the engineman will soon find out, from experience, how long the packing will last. The life of leather packing varies considerably according to the quality of the water or other liquid pumped, and also the quality of the leather. In many collieries, where new leathers have to be put in every day, in fact, they have duplicate pistons, so that one is made ready while the other is working.

The knocking of a pump is produced by one of the following causes: faulty or leaky joints in the suction pipe; the pipe being too small in diameter for the size of pump; or the suction valves are not working properly, so that the working barrel is not perfectly filled with water at each stroke, the knocking being produced by the flat surface of the piston or plunger meeting the water.

The writer has frequently had to examine pumps which did not give satisfaction, that were covered with dirt to such a degree that it was impossible to see the joints of the covers, which were originally polished bright, before thick coatings of filth had to be scraped off. The engine in the next room was beautifully cleaned, polished perfectly bright, and almost good enough for a drawing-room. On asking the reason, the reply received was, "Oh, it is only a pump." Why should the pump, which is in many cases quite, and in some cases more important than the engine, not receive the same attention? Surely a well-attended pump will last longer, work better, cause less anxiety, and be less liable to get out of order. The writer's advice is: keep it clean, nicely painted a clean looking plain color and in good order; it will then be a pleasure to the attendant instead of a constant source of anxiety and trouble. When you are looking after the interest of your pump, you are also looking after your employer's and your own.

There is an appliance for raising water which is not, strictly speaking, a pump, but which, at the present moment, is attracting a great deal of attention. Its principle is very little understood. In books it is hardly ever mentioned, and when noticed there is only a very scanty allusion to it. This is the air lift, or, as some call it, the air-lift pump. It is not by any means a new invention, but to Mr. Pohle, of Arizona, is due its practical form; to Mr. G. Y. Murray, of London, is due its introduction into England in 1894. It consists of a water pipe and an air pipe. Part of the water pipe is immersed in the water in the well, and the air pipe reaches to the bottom of the water pipe. Air under a certain pressure is discharged into the water pipe, thus raising the water, the air forming, as it were, alternate pistons of air and water in the rising main, not rising in bubbles as might be expected. The theory is this: If an open pipe is sunk in a vertical body of water and air is forced in the pipe, the entering air current, by its friction against the water, carries it. It has also been found that when the air is not forced into the bottom of the pipe, but is merely allowed to escape, the water is raised in the pipe. This is due to the lessened weight in the pipe owing to the space occupied by the air. Thus, suppose the pressure at the mouth of the pipe due to the head of water outside to be 6 pounds per square inch, if the air inside occupies one-third space and the water occupies two-thirds of the space, then the pressure at the mouth of the pipe, due to the weight of the water inside it, will be only 4 pounds per square inch. Of course the water will rapidly flow into the pipe under these circumstances. Supposing the bubbles of air in the pipe are very small, so that they cannot rise freely through the water, we have really a mixture of the fluid. The specific gravity will be less than that of the water outside, and the water will rise because the interstices between the bubbles are too small for the water to flow down between them and exert its full head; or, on the other hand, if we go to the other extreme, and pass in air bubbles so large that they completely fill the bore of the pipe, then we will have alternate layers of air and water. In this case again the water at the top of the pipe is shut off from communication with the lower end, and cannot exert the full hydrostatic pressure there due to its elevated position.

At the beginning of the operation the water surface outside the pipe and the water surface inside are at the same level; hence the vertical pressure per square inch is equal at the submerged end of the pipe, outside and inside. As the compressed air is forced into the lower end of the water pipe it forms alternate layers with the water, so that the pressure per square inch of the column thus made up of air and water, as it rises inside the water pipe, is less than the pressure per square inch outside the pipe. Owing to this difference of pressure, the water flows continually from the outside to within the water pipe by gravity, and its ascent through the pipe is free from shocks, jars, or noise.

These air sections, or strata of compressed air, form watertight bodies, which, in their ascent in the act of pumping, permit no slipping or back-flow of water. As each air stratum progresses upward to the delivery end it expands on its way in proportion as the overlying weight of water is diminished by its discharge. Therefore, the air action, which may have been 50 pounds per square inch at first, will be only 1.74 pounds when it underlies a water layer of 4 feet in length at the top, until finally this air section, when it lifts up and throws out 4 feet of water, is of the same tension as the normal atmosphere; thus proving that this pump is a perfect expansion engine.

In wells bored through sand strata, and having a strainer at bottom of the well casing, the top of the uptake pipe may be closed and a sudden back pressure exerted on the well, the flow of water reversed, and the sand embedded against the strainer removed. After thoroughly cleaning a well the apparatus is adjusted to its regular duty.

In the use of compressed air in pumping from artesian wells is secured the beneficial result from aeration. The air is thoroughly mixed with the water, giving it a pure and sparkling appearance. This is a point worthy of the consideration of every brewery depending upon artesian water for brewing purposes. It is also important to factories where the employes use artesian water for drinking purposes.

It is frequently remarked that the air lift is not economical; that is in some respects quite correct, but there are many things to take into consideration. An air lift is like ordinary pumps if adopted in the proper situation. No pump or appliance for raising water is suitable for all purposes. If we have a large, dug well, and an economic steam engine, it will not pay to put in an air lift; but if we have a bore-hole, and we want the greatest amount of water possible raised from it, use an air lift. If we have a well or bore-hole a distance from an engine house and boiler, where we can place our compressor, then an air lift is economical, as we can do with less men, and lose very little air pressure in comparison with the loss of steam by condensation.

In the air compressing system the losses of energy consist of:

The head expended in producing the commotion at the entrance to the descending shaft.

The head necessary to impart the velocity.

What may be called the "slip" of the air bubbles—that is, the amount by which their velocity falls short of that of the water. If, for instance, the bubbles are of a size to raise 9 inches in still water, then, in water moving with a velocity of 60 inches, 9-60 or about fifteen per cent of the energy will be lost.

The friction of water in the several passages.

The marked increase in efficiency, as the pressure of air is reduced to approach that corresponding to the head of water, is probably due to the very considerable decrease in the ratio of power, and consequently in the loss by friction.

In the original Pohle air-lift pump, tested by Prof. Randall, in company with Messrs. Browne and Behr, the following efficiency was shown:

For $\frac{H}{h}$ =	0.5	50 per cent.
"	1.0	40 per cent.
"	1.5	30 per cent.
"	2.0	25 per cent.

in which h = height of water in the well in feet, H = height to which the water has to be delivered.

The great reason why the air lift has not made quicker progress and come into more frequent use is that there are so many attempting to make and fix them who know nothing about them, and they are recommended for any purpose whether suitable or not for the special requirements.

The success or failure of an air-lift pump depends greatly upon the air compressor and the pipes being of proper proportions and design. If we use air at the pressure of 200 pounds per square inch, and compress it in one cylinder, we cannot of course expect good results and economy. In such case we must have a stage compressor—that is, compress the free air in a large cylinder, say, to 50 pounds per square inch, send it through an intercooler into a smaller cylinder, where it is compressed to the final pressure of 200 pounds per square inch.

The most suitable cases where an air-lift pump should be employed are:

Where water is not within reach of a suction pipe.

Where the deep-well pump does not lift enough water.

Where a larger quantity of water is required than can be obtained by pumping in the ordinary way.

Where the offensive gases from the artesian well deteriorate the potable qualities, as the air mixes with the water and removes the offensive gases.

Where a number of wells have to be operated with deep-well pumps to get the amount of water desired—Public Works.

SCIENCE NOTES.

An interesting report compiled by M. le Commandant F. A. Chaves, director of the meteorological service in the islands of Azores, has been presented to the Maritime Congress of Lisbon upon the subject of "Communication by Means of Wireless Telegraphy in the Azores." In the course of this statement the author points out the utility of wireless telegraphy in the archipelago for publishing information concerning wrecks and of ships abandoned in the North Atlantic, which drift toward the Azores. M. Chaves reports that in the last ten years forty-four vessels have suffered damage, and possibly many others total loss, by collision with these derelicts. By wireless telegrams passing ships could be warned of this danger. He also points out that in view of the Azores being in touch with our weather bureau, the islands might form a center, from which Europe could be informed daily of the position of maximum and minimum barometer in those parts, two or three points through which the mean isobar of 30.00 inches passes, and of the position of tempests or storm centers. Efforts are already being made to carry out some of these objects. A proposal has been made for the establishment of a wireless telegraphic system, but it has not yet been adopted.

The work of Prof. H. N. Morse and Dr. J. C. W. Frazer, his assistant, during the past year in investigating osmotic pressure has been along two quite distinct lines. It had been found that a porous wall, which affords an effective support for the osmotic membrane, is sometimes produced at the potteries, though rarely, and then in only a few out of many cells, and it had been discovered, through a study of thin sections, that the structure of such porous walls differs in a characteristic manner from that of others which do not adequately support the membrane. The greater portion of the year was devoted to the molding and burning of different clays and clay mixtures and to a study of the properties of the products, the end in view being a discovery of the conditions which are favorable or unfavorable to the production of that peculiar structure of porous wall which is known to be essential. A large number of experiments of this kind have been made and a considerable amount of data accumulated which it is thought will be of use in the solution of the problem. The progress of the work has been considerably retarded by the necessity of devising and constructing new appliances, some of which involved a large amount of preliminary experimentation.

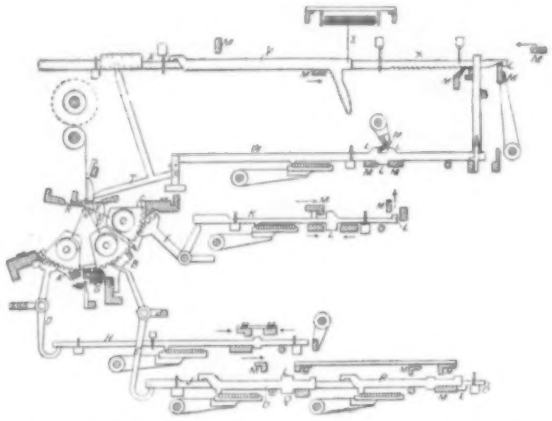
The sludge in the septic tanks of the sewage disposal system of Barrhead, England, has never been cleaned out in the six years they have been in operation, according to a paper read by Mr. William Shanks before the Sanitary Institute at Glasgow, yet the works have not lost their efficiency during that time. The disposal plant consists of two grit chambers, four septic tanks and eight filters, the total filtering area being about 2,540 square yards. They were designed to deal with the domestic sewage of 10,000 people and a small amount of roof drainage, with a total maximum flow of 400,000 imp. gal. per day. Surface water and manufacturing wastes are discharged in a stream, and the road detritus is not permitted to enter the tanks. At the end of the tanks next to the filters there is a scum on top about one inch thick, while at the other end no scum is present. The sludge at the bottom of the tanks toward the outlet end is about 3 feet deep; at the inlet end there is none at all. The surface of the filters is occasionally broken up as the scum gathers on top of them. The total cost of the plant was about $32,860, while the total operating expenses, including an attendant, repairs, etc., are about $390 a year.—Eng. Record.

Dr. W. E. Hoyle, of the Manchester Museum and president of the Manchester Entomological Society, gave an illustrated lecture at Manchester University on "Recent Researches in Mimicry." It is well known, he said, that animals of different groups resemble their surroundings, and that they do this in such a way as to acquire concealment. Striking instances of protective resemblances in the insect world were shown—resemblances in coloration and form. "Mimicry" was, the lecturer thought, not the correct word to use in these matters. Resemblance was a better word, because a mimic was a conscious imitator; but no one supposed that butterflies of different species which resembled each other were conscious imitators. Dr. Hoyle referred to the explanations which have been offered at various times of these resemblances. The explanation, he said, now generally accepted was that the resemblances were due to the action of natural selection. The difficulty in accepting this view was not nearly so great as that which confronted the advocates of the theories that the phenomenon was accounted for (1) by the influence of environment, (2) by evolution due to some internal cause in the structure of the animals, or (3) by sexual selection. In his opinion this was a case of the action of natural selection. Certain forms had been favored in the struggle for existence; they had been preserved while others less fortunate had been weeded out. He appealed to naturalists to do all they can to add to the stock of knowledge on these points.

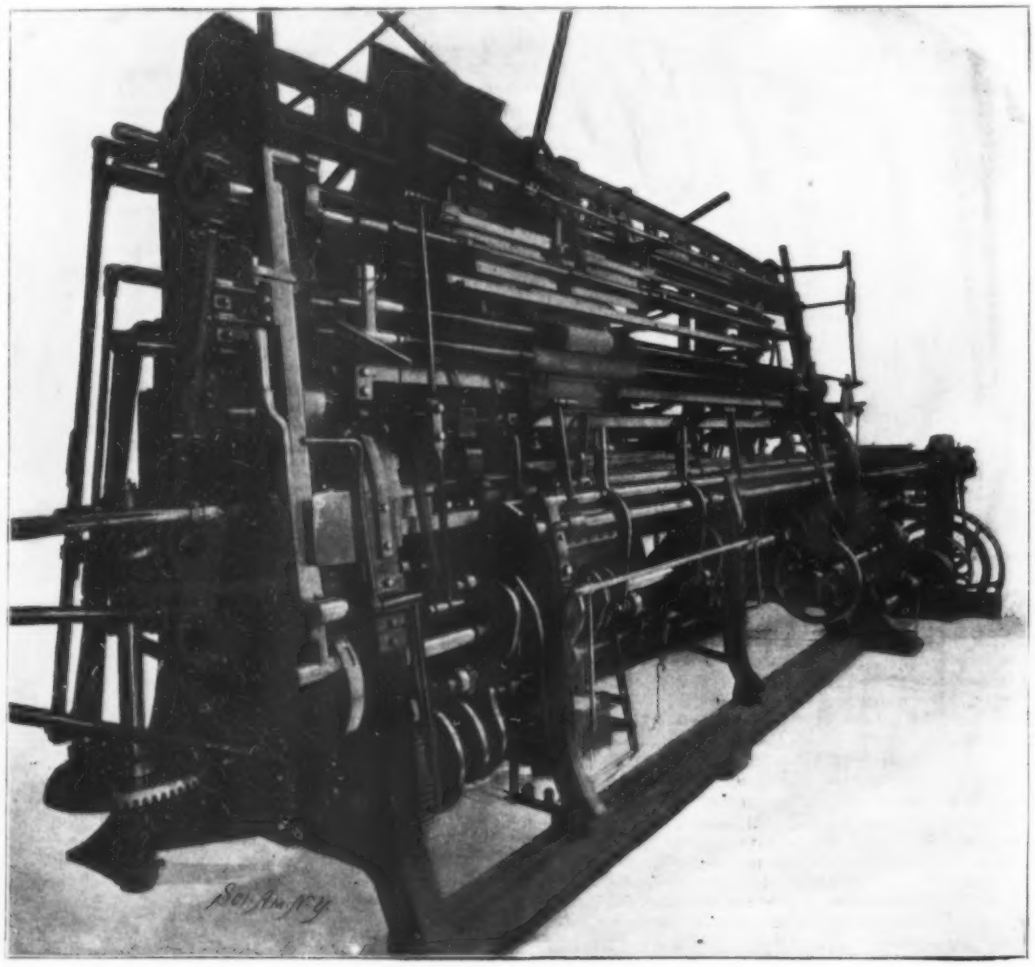
THE MATITSCH LACE-MAKING MACHINE.

By A. MATITSCH.

THE Levers lace machine, the one which has for many years supplied the greater proportion of machine-made laces, comprises mechanisms both intricate and ingenious, and produces an article which almost every-



CROSS SECTION OF LACE-MAKING MACHINE.



FRONT VIEW OF THE LACE-MAKING MACHINE.

body knows and values. The machine is, however, limited in its scope, and it does not require an expert to distinguish the difference between its products and real lace. For some years attempts have been made to perfect a machine which would be capable of imitating torchon and other hand-made laces, but until recently no mechanism has been devised which would properly and economically fulfill the necessary conditions. These difficulties, however, appear to have been overcome in the Matitsch machine, which we have seen working at Continental Works, Nottingham, the works of the well-known machine maker, Mr. Hooton. It is not the first machine which has essayed to manufacture real lace, for there are two machines which are well known on the Continent, and also in Nottingham, which have for some time past been turning out certain varieties. One is of German construction, but is only capable of making single interlacings or twistings, and so is only suitable for the plainest kind of laces. The other, a French machine, is very ingeniously constructed, but as it can only manufacture one narrow strip of lace at a time, its production is very small as compared with the cost of the machine.

The Matitsch machine is largely a combination of the bobbinet and the English twist-lace machine, being in general appearance very like the latter, but its chief feature is the arrangement by which the carriages can be moved. Not only do these move backward and forward as in the Levers machine, but they can do so independently of one another, and are also capable of being moved any distance in a lateral direction.

The diagram is a cross section of the main portion of the machine, and it will be seen in this that instead of the usual two sets of combs, three sets are used—*A*, *B*, and *C*. The front and back combs *A* and *C* may be moved laterally by means of cams placed at the end of the machine, but the comb *B* is a fixture. The carriages are moved from the comb *A* to the comb *B* by pickers *D*, the last portion of the travel being caused by the toothed wheel *G*, while the picker *F* propels the carriage from the back comb *C* to the middle comb *B*. Just underneath the comb *B* is a selecting or middle picker *E*, and it is by the use of this picker that a carriage in the middle comb can be directed into either the front or the back comb, as required. It will be seen that a push to the right will place the carriage in contact with the picker *F*, and so allow its being drawn into the back comb, while if the selecting picker *E* moves to the left the carriage will be taken forward by the toothed wheel *G* and the picker *D* into the front comb. With this selecting picker, then, any particular carriage can be placed in either comb, and as both the front and the back combs are capable of a lateral movement, the carriages are enabled to cross and recross each other to an almost unlimited extent, either by those in the front or back combs moving round those in the central comb, or by the outer combs traversing in different directions and the carriages then changing combs. It may also be mentioned that the pickers *D* and *F* move with their combs whenever these are slid laterally, and each picker always works in the same groove, however much the carriages may be changed about. The pickers *D*, *E*, and *F* are operated through their respective slides *H*, *J*, and *K*. Each of these slides has projections *L* which come in contact with reciprocating bars *M* which are arranged above and below the slides, the various contacts and the resulting motions being governed by a Jacquard. For instance, supposing it is desired to transfer a carriage from the front to the middle comb, the slide *H* is raised by the Jacquard so that the projection *L* on its upper side comes between the bars *M* just above it, while the projection *L* on its lower edge is raised clear of the bars *M* below. The reciprocating movement of the top bars *M* then carries the slide forward, while the upper toothed end of the picker comes inward and propels the carriage until it engages with the toothed roller *G*. If, under other circumstances, the carriage is required to remain in the front comb, the slide *H* is not lifted by the Jacquard, and it is prevented from moving forward by the bar *M* below it abutting against its lower projection *L*. The slide *K* is operated in a similar manner, but in its case the movements are in the opposite direction.

Without going too much into detail, it may not be out of place to say a few words about the card cutting for the motions just mentioned. This is somewhat different from the systems now in vogue, and in many respects shows a great advantage when compared with them, especially in supplying a ready method for checking or correcting the designer's or card-cutter's work. Raising the front slides causes the carriages to be moved from the front to the middle comb, or *vice versa*, while if the front slides are allowed to remain at rest the carriages remain in the front comb. As mentioned before, the reverse occurs in the case of the back slides, so that raising the slides keeps the carriages in the back comb, while leaving them down effects the transference of the carriages from the back to the middle comb, or *vice versa*. In consequence of this the Jacquard cards are cut in such a way that by laying the three cards of the three slides upon each other any error in cutting is at once made visible. For instance, when a carriage is required to be moved from the front to the middle comb, there must be a hole both in the front and in the middle picker card. If, on the other hand, it is necessary to bring a carriage from the back to the middle comb, there must be no hole in either the back or the middle picker card. If, therefore, before lacing, the cards for the front and middle pickers are laid over each other, there must be a hole through the two cards for the pickers which effect the movement of the carriage from the front to the middle comb, or from the middle one to the front. In the same way there must be blanks in both cards relating to the back and middle pickers when the carriages are operated between the back and middle combs. Any deviation from the correct cutting of the cards can thus be easily seen and remedied before working commences.

The operation of the middle or selecting pickers is somewhat different from that of the front and back ones. In order to make it possible for the machine to work at a good speed, the slide *J* has a double extension *O* and *P*, and these are provided with their own projections *N* and *Q* and separate bars *M*. The reason for this is to allow one extension to effect the movement in one direction, while the other operates the slide in the other, and by this plan the bars can be rapidly and accurately reciprocated without time being lost at the end of the stroke. For all these motions a bottom-bar Jacquard, and not an elevated one, is used. The machine is used for the production of numerous strips of lace of no great width, and bars carrying projections for bearing against the slides every repeat of the pattern, or sub-multiple of the pattern, transmit the movement from the Jacquard to the slide, and so save the intricate network of harness bands which would otherwise be necessary.

In ordinary twist lace machines it is essential that the needles which raise the twists and pattern threads enter immediately above the carriages in order to be in the proper position for doing their work. In the new machine, however, the carriages whose threads form the twists stand side by side and in one line when in their middle position. In order to raise the twists, therefore, the needles are inserted when this position has been arranged. The pattern threads pass between the combs *A* and *B* to the crossing point at *N*, and then pass sideways. When a carriage passes over the pattern bars on its way to or from the middle comb, the thread is raised vertically by this carriage from the hole in the pattern bar to the top of the carriage, and the needle seizes the pattern thread if it enters immediately above the carriage instead of just above the pattern bars. Two points are thus possible for the insertion of the needles—one when the carriages are in their middle position, and the other when they pass the pattern threads. With this arrangement it is necessary to have shortened carriages, and three sets of needles are used where it is customary to only use one. These three needles are shown at *R*, *S*, and *T*, and the first two are mounted on two different bars; but being mounted in bulk, they are operated all together when their separate bars move. The needles *S* are rather farther back than as shown, when all the carriages are in the outer combs; but after the carriages have reached their middle position these needles are pushed forward and enter immediately above the carriages and between their threads. The needles *S* are thin blades, which at their upper rear ends are imbedded in cast tin, so that a thread located between two such needles will, when the needles are moved forward, project vertically upward to the point *N*.

The threads of the carriages that move from the front comb into the middle comb, and then into the back comb, enter into the spaces between the bar *U* as they pass the middle comb. When this has taken place the back comb moves laterally (if the pattern requires it), and along with it move the bar *V*, the needles *S*, and this last-mentioned bar *U*. The needles *S* then move forward between the threads, and as a consequence the carriage threads are placed between

the needles *S* in the spaces of the bar *U*, but in different vertical planes. These two sets of planes, however, must be made to coincide, so that the needles *T* may be able to properly enter between the threads, and for this purpose they are brought out from between the teeth of the bar *U* and caused to enter those required by the position of the threads between the needles *S*. This is done by a forward movement of the bar *V* (effected by cams and levers) and the needles *S*, while at the same time the bar *U* moves backward. As this takes place the threads come out of their places without any appreciable loss of tension, and are moved laterally until they reach their desired position between the needles *S*. Then the needles *S* and the bars *U* and *V* are returned to their original positions, while the threads between the needles enter the spaces between the teeth lying opposite to them, where they remain until forced away by the bar *V*.

At the same time as the threads of the carriages coming from the middle comb fall into a plane perpendicular to the combs and are passing through the vertical line and away from the point *N*, the needles *R* enter between these threads. The carriages stand with their lower ends immediately adjacent to the holes in the pattern bars at this point, and therefore raise the pattern threads so that as the needles *R* are inserted these threads are caught. The needles *R* then enter between and lift the threads to the point *N*; but before this has occurred the needles *S* have adjusted the threads of the carriage entering the back comb in the tooth spaces of the bar *U*. The needles *T* then enter immediately above this bar and raise the threads to the height required by the pattern. These needles *T* are moved separately—not collectively like the other two sets—and so are able to perform an appreciable part in the formation of the pattern. They are retained in position by a guide composed of thin blades which allow a vertical, but prevent a lateral, movement. The needles *R* are drawn back clear of the threads after each insertion of the needles, *T*, but this is not possible with the needles *S*, between which the threads of the carriages in the back combs are constantly passing. In order, however, to prevent the lateral movements of this comb affecting the tension of the threads, the bar which carries them is connected with the back comb, so that comb and needles are always moved to the same extent. The needles *T* are operated by two Jacquards, one of which determines when any needle has to be withdrawn, and the other the height to be moved. The slides *W* are the mediums through which the needles are withdrawn, and also by which they are inserted when they have reached their lowest position. To withdraw the needles, the slides *W* are raised and drawn back in a manner similar to that described for the picker slides, although arrangements are made for reinserting them immediately after each withdrawal.

The raising of the needles *T* is effected through the slide *X*, which is shown in the diagram in its extreme forward position. As this slide is drawn back the needles rise, and this is performed by a bar during the first part of the movement, but is afterward taken up by the Jacquard, which, after the initial movement, is capable of giving twenty different heights. Each slide *X* carries an attachment *Y* having a projection on its underside carrying twenty steps. A bar *M* slides against the steps on *Y*, always having the same traverse, but according as the attachment *Y* is raised by the band *Z* from the dropper Jacquard, so does it transfer a varying portion of its movement to the steps on *Y*, and consequently to the needles *T* through the slide *X*.

The above description will give a rough idea of the mechanical features of the machine, it being obvious that a detailed description of the cams and levers for operating the acting parts would take up too much space. Whatever the future of the machine may be, it is already a mechanical success.

METEOROLOGY IN THE BRITISH EMPIRE.*

By SIR JOHN ELIOT, K.C.I.E., M.A., F.R.S.

MY address consists of three parts, viz.:

(1) A brief sketch of the broad features of the meteorology of India in their relations to the general meteorology of the Indo-oceanic region.

(2) Statement of abnormal features of the meteorology of that area for the unique period 1892-1902 illustrating the remarks in the preceding sketch.

(3) Suggestion of the co-ordination of the meteorological observations of the British Empire and the creation of a central office for the investigation of problems of general meteorology.

India is the most typical example of monsoon conditions, that is, of opposite air movements of six-monthly period which, in its case, depend on the annual temperature changes in the sea and land areas of the Indian Ocean and continent of Asia. The monsoon conditions in India are intensified by its unique position and topography. It projects southward into the Indian seas over 15 deg. of latitude, and is protected northward by the vast barrier of the Himalaya Mountain range and Tibetan plateau. The axis of the Himalayan range is at least 2,000 miles in length and has an average elevation of more than 20,000 feet. The extent of country more than 10,000 feet in elevation to the north of India is from 300 to 500 miles in width. These figures will give some idea of the magnitude of India's northern barrier.

During one period of the year there is an outflow in the lower atmosphere from land to sea. The direction of the lower air drift in India is determined in part of the lay of the mountains and river valleys, and is from northeast over the greater part of the Indian seas. January is the month most typical of this air movement and of the accompanying weather conditions.

During another portion of the year the lower horizontal air movement is from sea to land. This movement is much steadier and more powerful and influential in every respect than the former. July and August are the months most representative of the totality of the weather conditions of this period.

Conditions similar to those of January prevail in their entirety from about the middle of December to the end of February or middle of March—the period known in India as the cold weather or cool season. The lower horizontal air movement in India during the period has its origin in Upper India, where it is very feeble, and whence it increases seaward and is of moderate force in the Bay of Bengal (mean force 2 to 3, Beaufort scale) and the Arabian Sea (mean, 2 to 4). It is fed to a certain extent by drift down the river valleys, and passes in the northwest India frontier hill ranges. There is, on the other hand, no general drift down the Himalayan River valleys or across the main ranges from central Asia. The normal air movement in the western Himalayas (and perhaps the whole range) is an alternating up and down, or day-and-night movement, depending upon the diurnal heating and cooling of the plains of northern India. Hence India (in its lower air movement) is at this time completely shut off from central Asia.

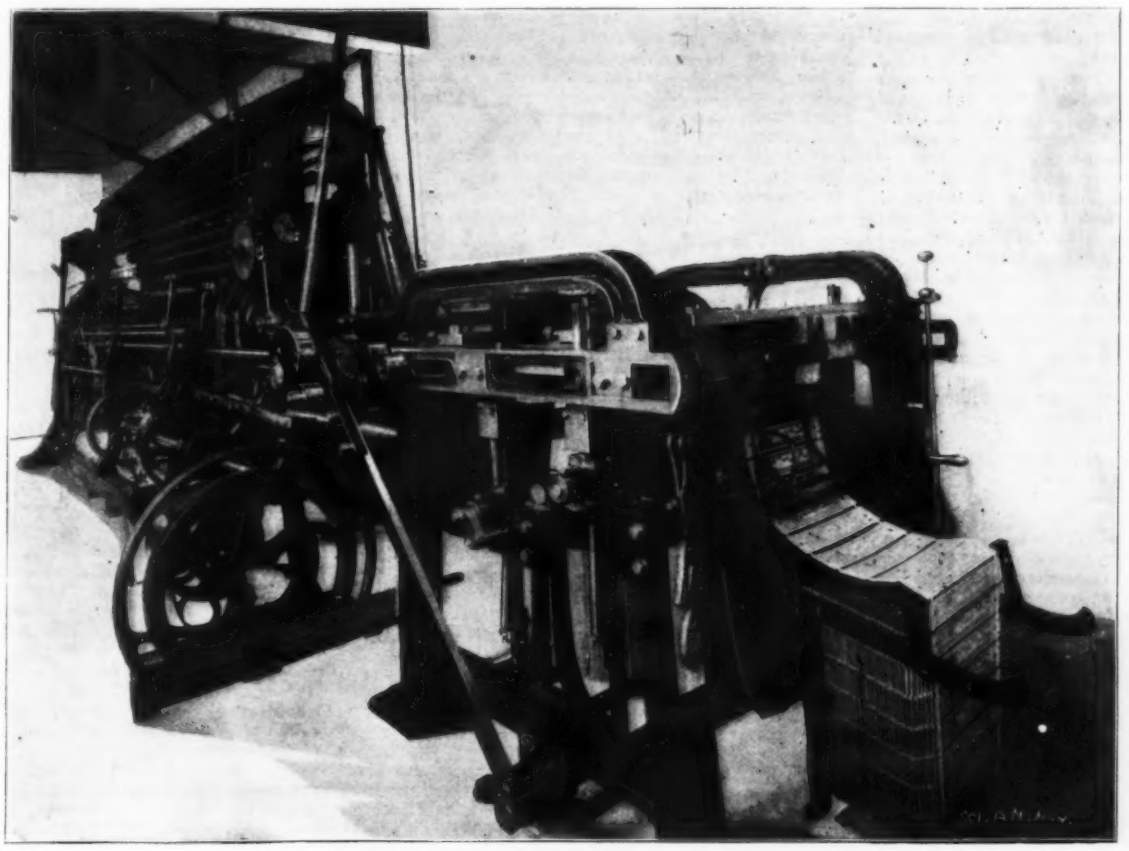
The lower air movement is continued over the Indian seas southward to a region of vertical movement over a narrow belt a little to the south of the equator. This belt is also the goal of the lower air movement of the southeast trades circulation at this time. The equatorial belt of calms is hence the termination of the lower air movement of the southeast trades and northeast monsoon. It is chiefly an area of uptake, and of outflow northward and southward, to replace the lower air inflow from the distant south and north. The influx to the Indian land area occurs chiefly or entirely in the upper and (perhaps) middle atmosphere. There is also, as indicated by the wind directions in the lower Assam and Burma hills, an influx from the adjacent seas in the upper portion of the lower atmosphere.* The diurnal land and sea breezes alternate with great regularity on the west coast south of Gujarat during this period, but probably do not contribute to the general upper influx compensating in part or whole the lower outflow.

The circulation over the Indo-oceanic region hence consists at this time of two semi-independent circulations, with a common sink or goal for the lower air movement, which shifts with the season and with the relative strengths of the two movements. It is hence probable that they react on each other to some extent, and possible that general abnormal actions may affect the two similarly.

The normal weather during the period is similar to that which obtains in anticyclonic periods during the summer in central Europe—viz., the prevalence of light winds, with clear or lightly clouded skies, low humidity, moderate temperature, and large diurnal range of temperature, with a bracing, exhilarating atmosphere.

It is interesting to note that the air movement in India itself is from opposite directions in northern India and the peninsula, with a belt of unsteady movement over the area of the Vindhya and Satpura hill ranges. The variations of weather conditions from the normal are as a rule inverse in these two regions—viz., extra-tropical and tropical India.

The season of the opposite air movement is present in its most complete form in July and August, and lasts from the beginning or middle of June to the middle or end of September. It commences as a lower air movement in an anticyclonic region over the South Indian Ocean, and is thence continued northward to Abyssinia, South Arabia, India, and Burma. Persia, Afghanistan, and Baluchistan (where dry hot northwest winds chiefly prevail) are outside the field of



REAR END VIEW OF THE LACE-MAKING MACHINE.

* Read before Subsection of Cosmical Physics of the British Association for the Advancement of Science.

* In India the lower atmosphere may be defined as from 0 to 5,000 feet, the middle atmosphere from 5,000 to 15,000 or 20,000 feet, and the upper atmosphere above 20,000 feet.

this movement. The direction of the movement is from south, with more or less easting to the south of the equator, and with more or less westing to the north of the equator, dependent in part upon the earth's rotation and in part upon local conditions and the influence of neighboring land areas, and hence more effective in the Bay of Bengal than in the Arabian Sea. This lower air current advances over an extensive tropical oceanic region before it reaches southern Asia, and hence arrives charged with vast stores of aqueous vapor, which it discharges chiefly over the peninsulas of southern Asia and the mountain region of Abyssinia.

The regions of rainfall indicate the areas of upward movement terminating the lower advance of the current. The circulation is undoubtedly maintained in large part by the release or addition of energy due to the condensation of its enormous stores of aqueous vapor. The lower air movement is of very considerable elevation, estimated at 15,000 to 20,000 feet in India. Above it is the outward upper return movement, in part only compensatory, and in part probably slowly filling up the central and southern Asian low-pressure region. The movement exhibits some interesting features in India, due to the fact that of the three areas to which it is mainly determined India alone is subject to a double influx from two sea areas in opposite directions. The current from the Arabian Sea passes eastward across the Malabar, Konkan, and north Bombay coasts, the peninsula and central India. The Bengal current is deflected in the north of the Bay and Bengal, and advances in a westerly direction up the Gangetic plain. Between the areas or fields of the two currents (roughly proportional to their relative strength and importance—viz., about 2 to 1) is a debatable area of variable winds and low pressure. This trough of low pressure varies in position with the relative strengths of the two currents. The cyclonic storms of the period, which are of comparatively frequent occurrence, advance along the trough. It is hence a factor of considerable importance in determining the distribution of the rainfall of the period. The trough is purely a resultant of the peculiar conditions of the air movement, and is not the cause of that movement; in other words, it is determined by it, and does not determine it.

The transformation of the double circulation of the northeast monsoon period into the single circulation of the southwest monsoon over the Indo-oceanic region next requires consideration. It is evident that the chief stages in this change are (1) the discontinuance of the vertical movement over the equatorial belt; (2) the extension of the trade winds of the southeast trades across the equatorial belt, with an accompanying increase of pressure and of horizontal air movement; (3) the continuance of that northerly movement over the Indian seas into the peninsulas of southern Asia.

The marine data of the Indian seas collected during the past fifteen years establish fully that this transformation is primarily due to actions in the Indian Ocean, producing a movement resembling in many respects that of a bore or storm wave. The actual transition may hence be described as catastrophic, due to impulsive action.

It is preceded in India by a period of preparation (as it may be termed), when pressure and other conditions are slowly established in southern Asia, which directly contribute to the advance of the monsoon winds over the Indian seas, but which in no way assist the preliminary burst across the equator, the first stage toward the establishment of the southwest monsoon circulation.

This preliminary period is the hot weather season, lasting from about the middle of March to the middle of June (on the average in northern India). During this period temperature increases rapidly until the last week in May or first week of June, when maximum day temperatures ranging between 120 deg. and 125 deg. are usually recorded in the driest and hottest interior districts of northern and central India. Pressure decreases *pari passu* in the heated land areas of southern Asia, which become areas of low pressure and indraught relative to the neighboring seas. The indraught only extends to a comparatively short distance landward and seaward from the coasts, more especially in the larger sea area, the Arabian Sea, over the center of which light variable or northerly winds obtain even immediately before the advance of the monsoon currents. In the interior of northern and in central India exceedingly dry and hot westerly winds prevail with great steadiness.

The weather in India during this period depends almost entirely upon local thermal actions and contrasts of temperature and humidity conditions. Skies are generally free from cloud, but the air is more or less charged with dust and is excessively dry (humidities of 1 to 5 being of occasional occurrence in northwestern India).

The characteristic features of the dry season are hence most strikingly exhibited immediately before the advent of the wet monsoon. There is no gradual change over the greater part of India from one to the other such as would occur if the furnace, or central Asia hot area, theory were correct. Over small isolated portions of India, including Tenasserim, Arakan, Lower Burma, Assam, Bengal, and Malabar, thunderstorms giving more or less heavy downpours occur in increasing frequency during the period. The rainfall is considerable to large in amount in these areas, and is of much agricultural value in some districts—e. g., in Assam for the tea crop. In those areas the transition to the rainy season is much less abrupt and spasmodic, the chief differences being that the rainfall in the wet season is more general and frequent, larger in amount, and rarely accompanies thunderstorms.

The transformation from the hot weather to the rains is usually effected between June 1 and 15. It commences in the equatorial belt with a considerable increase of pressure and air movement accompanying a strong rush of southerly winds, the continuation of southeast trade winds, across the equator. If the burst be sufficiently strong the rush is continued northward over the Indian seas as a wave of disturbance, squally weather, heavy rain, and much violent electric discharge or action, invading areas characterized previously by light and variable winds and fine weather. The disturbance usually increases with its northward advance, and frequently, when it reaches latitude 12 deg. to 16 deg. N., it concentrates into a cyclonic storm. Such a storm almost invariably marks the commencement of the monsoon in the Bay of Bengal, and in about two out of five years in the Arabian Sea. The advancing humid currents in the rear of these initial cyclonic storms or waves of disturbance march over the sea areas in a few days, and thence cross the coasts toward which they are determined by the low-pressure regions in the land areas of southern Asia, where they produce an almost complete reversal or transformation of the weather conditions, the result of which is that moderately high temperature and small diurnal range of temperature, great humidity frequently approaching saturation, much cloud, and frequent rain obtain for the next three months over the greater part of India, until, in fact, the middle or end of September.

The reverse change—viz. the withdrawal of the humid southwest currents—then commences and is a slow process, requiring usually from two to three months for its completion.

This is due to a gradual decrease of strength, and hence to a fairly continuous contraction of the field of the current, and also of its elevation or thickness. The current first withdraws from northwestern India, being replaced by light, variable, or northwesterly land winds. These land winds increase in extension and volume with the continued contraction of the southwest monsoon current. The more important phases of the contraction and withdrawal of that circulation from India are of especial interest. The first phase, the retreat of the current from northwestern India, accompanies a rise of pressure over the Persian area and northwestern India, with a shift of the trough of low pressure from W. N. W. to N. or N. E. and corresponding change of direction of the average tracks of the storms of the period. This is followed after a short period of rain in northeastern India and Burma by a rise of pressure in Assam, Upper Burma, and Bengal, and the withdrawal of the monsoon current from those areas. The current then recurves over the center of the Bay, in the same manner as during the monsoon proper over the north of the Bay and Bengal, and is directed or determined to the west or Madras coast of the Bay, which hence receives frequent rain during a short period of about two months—the rainy season of the eastern and southern parts of the peninsula south of Orissa and Ganjam.

These rains were formerly described as accompanying the setting in of the northeast monsoon on the Madras coast. That, however, is a misnomer, as the true northeast monsoon winds are dry land winds, and the rain-giving winds of this period in Madras are those of the southwest monsoon in its retreat or contraction down the Bay. The period during which this rainfall occurs is hence now usually termed the retreating southwest monsoon.

The year in India may hence be divided into two monsoons of nearly equal length, viz.:

(a) The northeast or dry monsoon.

(b) The southwest or wet monsoon.

The first terms are based on the general direction of the air movement in the Indian seas during the periods, and the second on the most prominent feature of the weather in India itself. Of an average annual total rainfall of 41 inches (according to the most trustworthy calculation), at least 85 per cent falls during the wet season, and only 15 per cent during the dry season.

The dry monsoon in India is subdivided into—

(1) The cold weather period.

(2) The hot-weather period or transitional period of preparation for the southwest monsoon.

The wet monsoon is divided into—

(1) The southwest monsoon proper, or the period of general rains.

(2) The period of the retreating southwest monsoon and gradual slow establishment of the dry monsoon.

Each of these periods practically covers three months.

One of the most noteworthy features of the meteorology of India not referred to in the previous statement is that the storms of each period—viz., the cold-weather period, the hot-weather period, and the wet monsoon—are characteristic and special to the period. They are all in the broadest sense of the word cyclonic in character; but they originate under different conditions and exhibit very different features in each of those periods.

The disturbances of the cold weather are large shallow depressions which originate in the upper humid return current of the northeast monsoon circulation, chiefly in the Persian plateau region, and which drift eastward with a slight southing across extra-tropical India. Storms do not occur south of the Deccan or peninsula-dividing ranges during this period. These storms are chiefly remarkable for the frequent development of stationary secondary depressions in the Punjab, usually of much greater intensity than the primaries; a feature of which, I believe, there is no parallel elsewhere. They are of great importance, as they give the main snow supply to the western Himalayas and the light but general occasional rain required for the wheat and other cold-weather crops of northern India.

The storms of the hot weather are local disturbances of very limited extent, usually in large areas of slight depression, and are occasionally of remarkable intensity and great violence. In the areas to which the local sea winds of the period extend (more especially Bengal and Assam) they occur chiefly as local thunderstorms with violent winds and brief heavy downpours of rain, but sometimes as tornadoes rivaling those of certain districts of the United States in intensity and destructiveness. In the dry interior they occur as dust storms, usually without rain, and are most violent in the driest districts, including Sind, the Punjab, and Rajputana. Occasionally, when the convective movement is especially vigorous, they develop into hail storms of great intensity. The rainfall accompanying these hot-weather storms is of little general agricultural value except in the tea districts of Assam and Bengal.

Finally, the wet monsoon is characterized by the frequent occurrence of cyclonic storms of every degree of intensity and of very varying extent. The great majority of them originate in sea areas of nearly uniform temperature as disturbances in a massive current highly charged with aqueous vapor and subject to large variations of intensity and extension. The more prominent features of these storms, more especially of the most violent, including the hurricane winds, excessive rainfall, and the phenomena of the central calm and the accompanying storm wave, are too well known to require description. The chief importance of these storms, of which an average of about ten (of different degrees of intensity) occur every year during this period, arises from the manner in which they modify the distribution of the rainfall, discharging it abundantly over the districts traversed by the storms at the expense of the districts outside of their particular field.

The most important and variable feature of the weather in India from the practical standpoint is rainfall. Its value depends upon its amount and occurrence in relation to the needs of the staple crops. The measurement of rainfall is carried out, on a uniform system, at upward of 2,500 rain-gage stations. The average distribution of rainfall, month by month, and for each season, has been determined from the data of about 2,000 stations. It should, however, be recognized that the probability that the rainfall will conform exactly to this distribution in any year is nil. Average rainfall charts represent a distribution about which the actual varies from district to district more or less considerably, the local variation for prolonged periods being practically compensatory. Such mean or normal data and charts are undoubtedly of value, more especially for the determination of rainfall anomalies and their relations to pressure, temperature, and other anomalies. There is apparently a tendency to assign a greater value to these charts of mean rainfall distribution than they deserve. Charts showing the amount and time distribution of the rainfall best suited for the requirements of the staple crops would—for India at least—be more interesting and valuable. This is a work that I regret has, for various reasons, not yet been carried out by the Indian Meteorological Department.

In most regions in India a moderate variation (positive or negative) in the amount of the rainfall is of comparatively small importance, more especially if the precipitation occurs in amount and at intervals suited to the requirements of the crops. During the thirty-year period 1874-1903 there were six years in which the distribution of rainfall affected to a serious extent the crop returns over large areas, and the rainfall was not compensatory. In four of these years the drought was so severe and widely spread as to occasion famine, with its attendant calamities, over large areas. Severe drouths and famines occur at very irregular intervals. A noteworthy feature is that they frequently follow in pairs separated by intervals of two to four years.

(To be continued.)

EMANATION AND RADIATION.—M. Berthelot puts down some considerations on the subject of the new emission discovered by Blondlot which are intended to guide further research into the field of emanations in general. He points out that many of the so-called emanations may be due to gaseous matter condensed on solids, and which can only be discovered by the most delicate chemical reactions. Volatile substances contained in the atmosphere may be condensed at the surface of bodies, or emanations may proceed from traces of organic matter derived from living organisms. Some of these organic matters adhere in an unaltered state. Others produce phenomena of hydration, oxidation, and chloridation such as may be demonstrated in the case of metals and alloys placed in contact with alcohol, ether, or chloroform. The emanations observed may be of complex structure. Thus the emanation of phosphorus, the best hitherto known, contains not only phosphorus vapor, but also the vapor of several of its oxides, ozone, water and nitric acid. One of the difficulties of modern research is that the imponderable reactions are becoming more numerous and more delicate, and cannot be followed up by means of the balance, to which chemistry owes its rank as an exact science.—Berthelot, Comptes Rendus, June 20, 1904.

STARS: THEIR VARIOUS STAGES OF DEVELOPMENT AS REVEALED BY THE SPECTROSCOPE.

J. A. FORMOY, F.R.A.S., recently lectured most instructively before the English Camera Club. The following is an abstract of the paper:

The lecturer apologized for the abstruseness of his subject. It was to him, he said, a most engrossing one, and one which had occupied him for very many years. Some time before he lectured to the members on the subject of Nebulæ, and he intended to take up the thread of his argument from where he let it fall and speak of the next stage to nebulæ in star condensation and development.

The first slide showed a plain spectrum representing the dispersion of one small line of light. All the various rays of which the light was composed were bent out of their path on passing through the spectroscope, and their dispersion took the form of the colored band shown. The light of any incandescent solid substance, similarly treated, gave a like band of color. The hotter the source of light the more extended would be the spectrum at its violet end.

When the spectroscope was pointed to the sun a very extraordinary view was presented. Curious black lines appeared in the spectrum, in some cases crowded together, in others wider apart; in others again very fine or double. For a long time the meaning of these dark lines running transversely across the solar spectrum remained a mystery. Fraunhofer, with a tiny object prism, first discovered their existence in 1823. This pioneer worker with this prism only saw a few of the lines at first, the remainder being unnoticed owing to the inadequacy of his apparatus; subsequently, with the aid of a 4-inch telescope and a prism set suitably before it, a larger number of lines were discovered by him.

A mass of incandescent hydrogen glowing in its own light gives through the spectroscope only four lines—red, bluish-green, blue, and violet—instead of a continuous band of color. These lines always had the same fixed position in the spectrum, and the same width and intensity. Sodium was represented only by the well-known D line in the yellow, while the complicated spectrum of iron, on the other hand, had some 460 lines, ranging from red to blue. So it was with every element. Each had certain definite lines applicable to its own spectrum. The spectroscope thus furnished a means of identifying the elements beyond doubt. In 1859 Kirchhoff found that many of the bright lines of incandescent metals had their exact counterpart, both in regard to position and width, in the dark lines of the solar spectrum. These dark lines showed where absorption took place through vapors of metals and gases.

Kirchhoff made his first experiments with the two yellow lines of sodium because these were so easy to produce. As a matter of fact, it was so difficult to get rid of the sodium spectrum in the ordinary laboratory that it was something of a nuisance. In order to reproduce the two black lines found in the sun's spectrum, Kirchhoff took an iron tube 5 feet long, closed at each end with a piece of glass plate; along the interior of this tube he placed small and absolutely clean fragments of sodium metal, and exposed the whole to the heat of a furnace. Thus he obtained sodium gas. He then placed at one end an electric light and a spectroscope at the other, and threw the electric light through the tube. As a result, instead of the two yellow lines of sodium, he got two black lines, superposed on the colored spectrum of the electric light, and when he came to compare these with the two black lines in the same position in the sun's spectrum, he found them to be absolutely identical. Thus he was convinced that sodium was in the sun's chromosphere.

Then followed the identification of various other elements in our luminary by the same process. It was now known that the black lines in the sun's spectrum were due to magnesium, iron, calcium, nickel, aluminium, sodium, helium, hydrogen, and various other metals and gases common to our own planet. To a great extent the constiiution of our sun was known to us. It was composed of a central glowing mass, which represented the electric light of Kirchhoff's experiment; this was surrounded by an atmosphere consisting of incandescent gases of the various metals, etc., beyond that an atmosphere of hydrogen, higher still one of helium, and at the furthermost the corona, which was probably the true solar atmosphere, and lay outside the region of the colored prominences.

In reply to a question from one of the members, the lecturer further explained that the sodium in the sun's outer envelope was in a state of incandenscence, without which the lines could not be obtained. Were the sodium solid it would merely give in the spectrum a color band. In this connection a very pretty experiment might be tried. A tiny piece of sodium should be placed in a test tube and heated with an ordinary Bunsen burner; the sodium gas which would be given off if placed in front of a spectroscope would give the two yellow lines. Examined, while still hot, with a good petroleum lamp behind it, a curious reversal would be noted; the sodium would have cut out its own light, and produced two black bands superposed on the colored spectrum of the petroleum lamp.

Huggins, Rutherford, and Secchi followed in the steps of Kirchhoff. Secchi applied the spectroscope to the whole of the heavens, and discovered that while the planets gave the same spectrum as the sun (necessarily so, because they shone by its light), the fixed stars revealed a different order of things. The spectra of the stars differed from one another very considerably. Some were crowded with lines, others had very few lines indeed. It was found possible, however, to divide the stars into four types. The first type, the Sirian stars, consisted of those having one or two broad lines. The second, the Solar stars, resembled our own sun, and had a number of well-defined lines. The third consisted of those stars which had a number of lines crowded together and with peculiar "flutings" sharply cut off at the blue and shaded at the red end. The fourth gave a very faint spectrum consisting of a number of dark lines with fluting sharply cut off at the red end and shaded at the blue—all being suns in different stages of development.

In order to assist in tracing the earliest defined stage in the development of stars from nebulæ, the lecturer showed a photograph of the Pleiades, in which group there were but seven stars visible to the naked eye. The photograph, taken with a very long exposure on different nights, revealed 1,421 countable stars; another, with a longer exposure still, showed that nebulæ surrounded the principal of these orbs. It was only photography that revealed these nebulous structures; when observed under ordinary conditions no nebulæ were visible. The long exposure impressed them on the plate, and these stars had been as it were "caught in the act" of condensing.

The lecturer also showed a field of star spectra. Each star was seen simply as a spectrum, owing to the fact that there was a large prism before the objective which dispersed the light into spectra. These spectra greatly differed from one another, again illustrating the various stages in development in the fixed stars. Some were young, others a little older, others again old.

The first type of star to be noted was that in which the metal lines were so faint as to be all but invisible. In this type hydrogen was so prominent and intense as to overpower almost every metal that was present. At the same time, it was not present in equal force in all the "white stars." In the case of Sirius one had practically only the G line and the H line. There were, indeed, other lines of a very faint character, but hydrogen was overwhelmingly prominent. Another peculiarity in stars of this type was that the violet portion of their spectrum was very intense and prolonged, showing that the heat was very intense. The spectrum entirely differed from that of our sun. These were, in fact, the white stars of the heavens representing the first definite form after condensation from nebulæ, an atmosphere of hydrogen and helium surrounding them to an enormous exteat.

The second or solar order of stars consisted of those in which the metal lines were similar to those of our own sun, the typical star being Capella. In these also the hydrogen lines were prominent; but condensation and cooling had gone on to such a degree as to make the dark lines of numerous metals and gases distinctly visible. In α Procyon, for example, the majority of the lines traceable were due to iron, calcium, magnesium, sodium, nickel, cobalt, barium, etc.; other lines are also present, those of hydrogen being prominent.

In the third class of stars, the hydrogen lines, instead of being black, as hitherto, were bright; that is, colored, as would be the case when examining incandescent hydrogen in the laboratory. This type of star, as a rule, was variable. At one time it would shine brightly, and then would dwindle down until it nearly passed out of sight, when it would again revive and become bright. One hypothesis explaining the condition of these stars is somewhat as follows: The star itself had a small nucleus, but its atmosphere was so enormous that the light from the incandescent hydrogen on either side overpowered the dark lines emitted by the nucleus. The spectrum of this central nucleus would, therefore, be superposed upon the spectrum emitted by the whole of the atmosphere, and, as a result, the atmosphere being incandescent and more powerful than the nucleus, its bright lines were seen instead of dark lines, those of the nucleus being dark. There are, however, other explanations of the phenomenon.

The spectrum given by this third order of stars was similar to that of a sunspot. The lecturer exhibited a slide showing an outburst of hydrogen from the sun's disk as seen at the time of an eclipse. This upshot of hydrogen, when contrasted with the size of our own planet, was seen to be truly enormous. A photograph taken at Greenwich of the great sunspot of September, 1903, was also shown. This spot extended over very nearly five-millionths of the sun's disk. It was supposed that these spots were uprushes from the atmosphere of the sun forming the glowing clouds of vapor in the outermost solar envelope. Examined through the spectroscope, it was found that some of these were clouds of magnesium, others of sodium, etc., and that they generally had small bridges of incandescent hydrogen connecting their darkest portions. The two narrow sodium lines in this spectrum were found to be greatly thickened, showing that the pressure was very great.

The lecturer entered somewhat minutely upon the star Beta Lyræ, to the south of Vega. This was a variable star, taking 12 days, 21 hours, 47 minutes, and 13 seconds in which to accomplish its cycle. Its two maxima and two minima changes went on with unalterable regularity. By means of a slide, prepared at Stoneyhurst Observatory, illustrating the changes in this star's spectrum for each day of the above specified period, it was seen that some of the lines performed extraordinary caprices. When the various spectra were compared with the time of the variableness of the star it was found that they tallied to a considerable extent. There were a number of expianations to account for these changes. It was known that there were at least three sources of light—an incandescent gas giving off light of its own, and two further sources of light giving off two series of dark lines; but at another stage in this star's changes it was evident from its spectrum that there must be either four sources of light or that the same two series of dark lines must be superposed on a consider ably widened bright line. The general opinion favored the latter explanation.

The reason for the widening of the line might be illustrated by the case of a train traveling in the direction of the observer; if the light of its lantern were examined through the spectroscope it would be found that the advance of the engine caused the wave-length to shorten and all the rays to shift to the violet. If, on the other hand, the train were going from the observer, all the rays would be shifted to the red, and the light waves would be lengthened. Light waves were closely allied to sound waves, in which the same principle was at work. As a train approached the observer the sound of its whistle would rise in pitch; as it went from him the sound would lower in pitch. The sound waves shortened as the train approached and lengthened as the train receded. By the shifting of the lines it was possible to estimate the velocity of a star in the line of sight; when the lines shifted to the violet end it was known that they were being shortened, and by calculating this shortening of the wave-length they could tell the pace at which the star was traveling.

This category of events, made visible by the agency of the spectroscope, showed that the various components of this star were in a state of very rapid motion. Calculating by means of the two edges of the F line, a certain great scientist had estimated that the pace at which it was moving toward us was 68 kilometers per second of time. He further calculated that the circumference of the orbit was 74,000,000 kilometers, and the distance of the center of gravity 24,000,000 kilometers. By comparing the spectra of this star in its various stages, it was possible to learn the metals of which it was composed. The general idea now was that there were four suns revolving round each other, their eclipse and re-eclipse giving the appearance of these lines. A great deal more scientific work would have to be done, however, before the vagaries of this spectrum could be explained.

The last order of stars to which the lecturer called attention included those that were temporary or occasional. They were few and far between indeed, but stars sometimes blazed up in the heavens that had never previously been there. Their sudden transformation into the first magnitude would occasionally take place in 24 hours. Nova Persei was an example of this class. Ten days before this star appeared, in December, 1891, a photograph was taken of Perseus which gave no sign of anything remarkable; in less than 24 hours it came up from nothing to the first magnitude, outrivaling Capella in brilliancy. Its spectra varied greatly, and even while one spectrum was being photographed the motion in the line of sight shifted the lines. An enormous region of nebulous gas many millions of miles in extent evidently surrounded the star. During its continuance as a first magnitude star, hydrogen and helium shone out in its spectrum with enormous intensity. After a time it dwindled down to the third or fourth magnitude. In the course of three days it shifted from the third to the fifth and back again to the third. The change in the H line was so enormous as to show a motion in the line of sight of from 500 to 700 miles per second. The vortices, the storms, the hurricanes that occurred as shown by the different intensities in the hydrogen lines must have been beyond the power of any adjective to describe. Various explanations were put forward to account for the phenomenon. A solar system like our own might have been precipitated into a nebula. This was more likely than the alternative explanation—namely, that a very large body had crashed into a faint star; in any case, for such an enormous mass of gas to develop in 24 hours the upheaval must have been truly awful, and the terrific motions and forces which were raging must have been appalling.

In order to show how the mass of gas could extend far beyond the nucleus of a star, the lecturer placed on the screen a photograph of this Nova surrounded by a nebula. He also showed the spectrum of the great nebula Orion and the trapezium stars, and pointed out how the beginning of the development of a star out of the nebula itself was to be traced.

To sum up the whole, all the stars were suns, and were different in constitution only because of their different stages of development from nebulæ. They might be classified according to the gradual cooling which had taken place, as white, yellow, red, and orange, and they ranged from the brightest, identified by the hydrogen lines, and few or no lines to those of the lowest group giving a very fafnt spectrum with crowded lines. In all of them were the same elements as in our own sun, and all of them had their part in the one grand development of the enormous universe.

In 4,334 stars of a magnitude only down to the fifth, 73 per cent were white stars (2 per cent of these having broad lines in their spectrum); 26 per cent were suns like our own; and 1 per cent were cold or cooling stars which would go out of light altogether so far as the spectroscope was concerned.

This science was still in its infancy, and this was an age of new developments. He felt confident that in a

hundred years' time the astronomer would be in a much better position to talk to the members of the Camera Club about the wonders of the universe.

[Continued from SUPPLEMENT No. 1519, page 24344.]

EXPERIMENTAL ELECTROCHEMISTRY.*

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SEVENTH PAPER.

Energy Required in Electrolysis—Practical Formula for Computing. Electrolytic Separation of Metals. The Rotating Anode in Electro-Analysis.

IN the last chapter it was pointed out that whereas a given current flowing for a given time would separate chemical equivalents of electrolytes, the energy absorbed in electrolytes of different constitutions was not the same. Now, why is it that some electrolytes require more energy to isolate the constituent parts than others? We have learned that 96,540 coulombs will isolate the *chemical equivalent of any electrolyte*, and we now learn that these 96,540 coulombs must be supplied at different electrical pressures for different electrolytes. The 96,540 coulombs without an electromotive force would not flow, and it is evident that we must have some electromotive force in order to have electrical energy. Now, the joule is the unit of electrical energy, and is the product of the coulombs by the volts in an electrical circuit, and we may have any amount of electrical energy we may wish by multiplying our 96,540 coulombs by volts or fractions of volts. To determine why some electrolytes require more energy (a higher electrical pressure with the 96,540 coulombs) than others, we need but to refer to the "heats of formation" of different electrolytes and the beautiful doctrine of the "conservation and correlation of energy." By "heat of formation" of a chemical compound, we mean the number of calories liberated (and sometimes absorbed) when one gramme-molecule of the substance is produced. To find the heat of formation of a chemical compound, a gramme-molecule of the substance is taken and its combustion in oxygen determined. According to the principle discovered by Hess, if we know the heat of combustion of a gramme-molecule of a compound, we may determine its heat of formation by subtracting the heat of combustion of the compound from the heats of combustion of the constituent elements. For example, the heat of formation of methane, CH_4, is determined by measuring the heat of combustion of the compound in oxygen in a suitable calorimeter, and the heats of combustion of its elements in the same manner, and subtracting one from the other as follows:

Heat of combustion of methane, CH_4 = 211,930 calories yielding CO_2 and $2H_2O$.
Heat of combustion of carbon, C = 96,960 calories yielding CO_2.
Heat of combustion of hydrogen, H_4 = 136,720 calories yielding $2H_2O$.

The heat of formation of a gramme-molecule of methane is found by subtracting 211,930 calories (its heat of combustion) from 96,960 + 136,720 calories (the heats of combustion of its constituent parts) as given:

$$\begin{array}{r} 96,960 \\ 136,720 \\ \hline 233,680 \\ 211,930 \\ \hline 21,750 \end{array}$$

∴ 21,750 calories = heat of formation of CH_4.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

Therefore, when the gramme-molecule of CH_4 is produced, a definite amount of energy is liberated; and according to the doctrine of the conservation of energy, this same quantity of energy must be absorbed again before the compound can be broken up into its constituent parts. CH_4 is not an electrolyte; the compound was taken to serve as an illustration. Below we have tabulated the heats of formation of a number of chemical compounds taken from the general tables in Ostwald's "Outlines of General Chemistry." These have been converted into small calories.

		Calories.
Hydrochloric acid	HCl	22,000
Water	H_2O	68,400
Sulphuric acid	H_2SO_4	193,100
Ammonia	NH_3	12,000
Nitric acid	HNO_3	49,100
Potassium hydroxide	KOH	103,200
Potassium chloride	KCl	104,300
Potassium bromide	KBr	95,100
Potassium iodide	KI	80,100
Potassium nitrate	KNO_3	119,500
Sodium hydroxide	KOH	101,900
Sodium chloride	NaCl	97,600
Sodium bromide	NaBr	85,800
Sodium iodide	Na I	69,100
Sodium sulphate	Na_2SO_4	328,800
Sodium hydrogen sulphate	$NaHSO_4$	267,800
Ammonium chloride	NH_4Cl	75,800
Ammonium bromide	NH_4Br	65,400
Ammonium iodide	NH_4I	49,300
Calcium hydroxide	$Ca(OH)_2$	214,900
Calcium oxide	Ca O	131,000
Calcium chloride	$CaCl_2$	169,800
Calcium bromide	$CaBr_2$	140,900
Calcium iodide	$Ca I_2$	107,300
Magnesium chloride	$Mg Cl_2$	217,300
Magnesium oxide	Mg O	143,900
Magnesium hydroxide	$Mg(OH)_2$	217,300
Aluminium hydroxide	$Al(OH)_3$	297,000
Aluminium chloride	$AlCl_3$	151,000
Aluminium bromide	$AlBr_3$	119,700
Aluminium iodide	AlI_3	70,400
Ferrous chloride	$FeCl_2$	82,100
Ferric chloride	$FeCl_3$	96,100
Ferrous sulphate	$FeSO_4$	235,600
Nickel chloride	$NiCl_2$	74,500
Nickel sulphate	$NiSO_4$	229,400
Zinc oxide	ZnO	85,800
Zinc chloride	$ZnCl_2$	97,200
Zinc bromide	$ZnBr_2$	76,000
Zinc iodide	ZnI_2	49,200
Cadmium chloride	$CdCl_2$	93,200
Cadmium bromide	$CdBr_2$	75,200
Cadmium iodide	$Cd I_2$	48,800
Cuprous chloride	$CuCl_2$	51,600
Cuprous bromide	$CuBr_2$	32,600
Cuprous iodide	CuI_2	32,500
Cupric sulphate	$CuSO_4$	182,600
Cupric nitrate	$Cu(NO_3)_2$	82,300
Mercurous chloride	Hg_2Cl_2	62,600
Mercuric chloride	$Hg Cl_2$	53,200
Silver nitrate	$AgNO_3$	28,700
Lead chloride	$PbCl_2$	82,800
Lead bromide	$PbBr_2$	64,500
Lead iodide	PbI_2	39,800
Lead sulphate	$PbSO_4$	216,200
Lead nitrate	$Pb(NO_3)_2$	105,500
Stannous chloride	$SnCl_2$	80,800
Stannic chloride	$SnCl_4$	127,300
Auric chloride	$AuCl_3$	22,800
Aurous chloride	AuCl	5,800
Aurous bromide	AuBr	—100
Aurous iodide	AuI	—5,500
Chloroplatinic acid	H_2PtCl_6	163,200
Bromoplatinic acid	H_2PtBr_6	88,400

There are of course many others given in a general table, including both organic and inorganic compounds, electrolytes and non-electrolytes, but it is believed that the list given includes a sufficient number of electrolytes to be of service in the laboratory. With such a table of heats of formation, and the doctrine of the conservation and correlation of energy, taken in connection with our important constant of 96,540 coulombs, we should be able to calculate the minimum voltage or electromotive force necessary, and consequently the energy required, to break up any chemical compound by electrolysis. It is simply converting heat energy into electrical energy. We must of course know the relation between the calorie and the joule, and should commit this to memory as a very important figure:

1 joule = 0.00024 calorie
1 joule = 0.24000 Calorie

Let us take one or two examples and work them out, developing a practical working formula for future use. We have already learned that electrolytes may be either chemical compounds in solution or in a state of igneous fusion. As we have dealt with many electrolytes consisting of substances dissolved in water, let us consider an electrolyte in a state of fusion by heat. Let us first take an electrolyte consisting of monovalent constituents, and consider it theoretically. Common salt, or sodium chloride, will serve our purpose, with its monovalent sodium linked to the monovalent chlorine. In calculating the minimum voltage necessary to isolate a chemical equivalent of sodium and chlorine, and the energy necessary to effect the electrolysis, we must consider the gramme-molecule as the basis of our calculation, which in the case of sodium chloride is 58.5, since sodium has an atomic weight of 23, and chlorine 35.5. Therefore 23 + 35.5 = 58.5. 58.5 grammes of sodium chloride is the gramme-molecule of the salt. Glancing at the table of "heats of formation" for the value found for sodium chloride, we find it to be 97,900 calories. When 23 grammes of sodium combine with 35.5 grammes of chlorine, therefore, to form 58.5 grammes of sodium chloride, 97,900 units of heat are set free. According to the doctrine of the conservation of energy, in order to decompose these 58.5 grammes of sodium chloride, an amount of energy equal to that liberated at the time of formation must be expended upon it to break it up. How much electrical energy, for instance, is the equivalent of 97,900 heat units? The heat unit is the calorie, and we have just learned that 0.24 Calorie is equal to the joule. 97,900 calories divided by 0.24 therefore gives us the joules necessary to effect the electrolysis.

$$\frac{97,900}{0.24} = 407,916 \text{ joules.}$$

We have learned that the passage of 96,540 coulombs will set free the chemical equivalent of any electrolyte, and we see from the above work that 407,916 units of electrical energy are necessary. In order that the passage of 96,540 coulombs should represent the expenditure of 407,916 joules, they must be supplied at an electrical voltage or potential of

$$\frac{407,916}{96,540} = 4.22 \text{ volts.}$$

To liberate 23 grammes of sodium and 35.5 grammes of chlorine, therefore, from 58.5 grammes of sodium chloride, we will have to expend 407,916 joules of electrical energy, and it will be necessary to have a voltage of at least 4.22 volts before an electrical current can be made to pass through. Let us take the case of a compound with a divalent constituent, for example magnesium chloride ($MgCl_2$) and theoretically and practically, if we may so speak, isolate the chlorine from the metal in the laboratory. By referring again to our table of formation heats, we find for the gramme-molecule of magnesium chloride that 217,300 calories are liberated. We have therefore:

$$\frac{217,300}{0.2400} = 905,415 \text{ joules.}$$

Now we are dealing with a divalent electrolyte, and according to Faraday's law it will require the passage

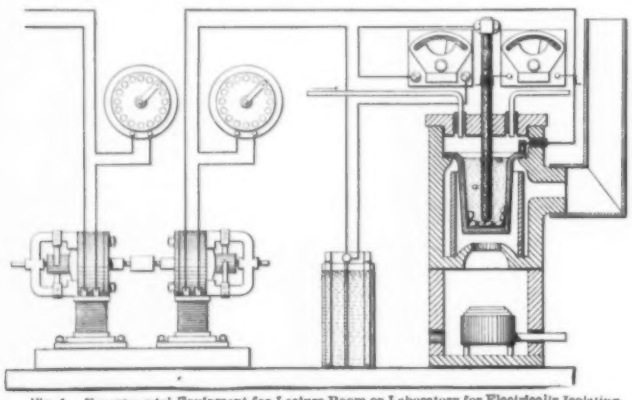


Fig. 1.—Experimental Equipment for Lecture Room or Laboratory for Electrically Isolating Metallic Magnesium from its Chloride. Motor-Generator with Rheostats at Left. Copper Voltameter in Center, and Small Fusion Furnace at Right.

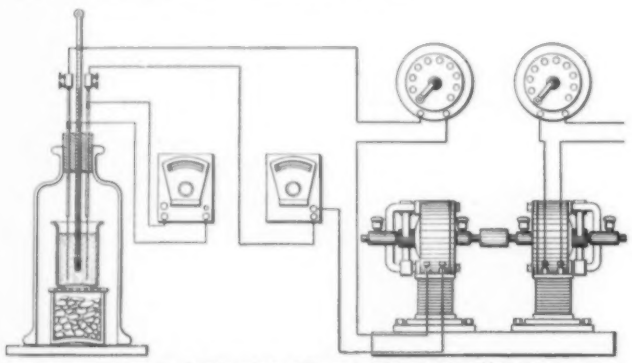


Fig. 2.—Apparatus for the Electrolysis of Concentrated Sulphuric Acid to Obtain as Electrode Products Hydrogen, Oxygen, Ozone and Free Sulphur which May be Exhibited upon the Anode and be Burned. Therefore, Sulphuric Acid May be Directly Broken Down into its Elements.

Fig. 6.—Experiment with Copper Sulphate Solution to Show Concentration Changes Wrought by a Feeble Current Flowing for a Long Time. The Electrodes are of Copper.

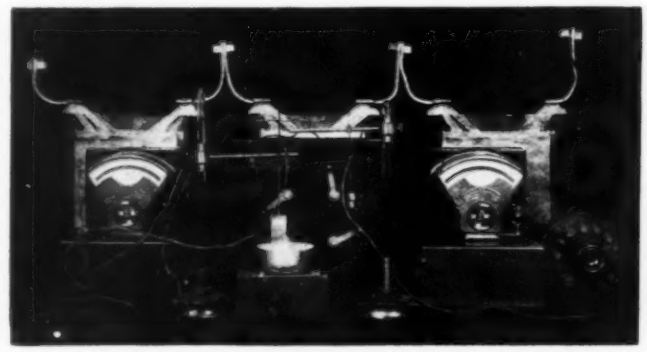


Fig. 4.—The Separation of Metals by Adjustment of Electrode Tension. Rheostats, Storage Batteries, and Electrical Instruments Are Shown Here in Practical Operation in the Laboratory.

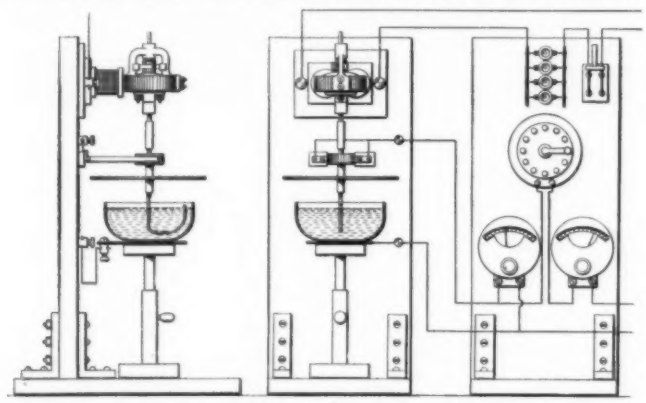


Fig. 5.—Easily Constructed Rotating Anode for Rapidly Conducting Electro-Analysis. With this Equipment an Electro-Analysis May be Completed in a Few Minutes, which would Require Several Hours to Accomplish in the Old Way.

of 96,540 + 96,540 coulombs to liberate the constituents, which gives us:

$$\begin{matrix}96{,}540\\96{,}540\end{matrix}$$
193,080 coulombs,

which must be divided into 905,415 joules in order to obtain the minimum voltage

$$\frac{905{,}415}{193{,}080} = 4.68 \text{ volts.}$$

It is evident that these minimum voltages are dependent upon the degree of accuracy attained in the determination of the heat of formation of the compound in the calorimeter, which of course is purely a thermochemical operation. It must be stated, however, as a matter of fact in an actual experiment with a fused electrolyte, that the calculated voltages are a little high, which is accounted for by the high temperatures of the fused compound. At the temperatures of igneous fusion the heats of formation have a lower value, apart from the fact that compounds are dissociated in the fused state. When in a state of igneous fusion, therefore, a voltage of something less than the calculated pressure will drive the electrical current through. Let us perform the experiment of electrically isolating the metal magnesium from its chloride, and measure the electrical energy required. Fig. 1 shows the equipment which we can use to the best advantage, both as a laboratory method of producing the metal, and also as a brilliant lecture experiment, where a large mass of the metal is produced and hammered out and ignited to produce the dazzling magnesium light. At the left in this illustration we have the motor-generator, with the controlling rheostats for supplying a heavy current at low electrical pressure. The furnace is of the small gas fusion type, which contains an iron pot for the electrolyte, and which as can be seen is made the cathode. The anode consists of a large rod of carbon passing through a tight-fitting cover. A large copper voltameter is depicted in the center for determining the number of coulombs passed, and electrical instruments are connected to the leads to indicate the voltage and current strength. For our experimental purposes an artificial carnalite will best serve our purpose for the electrolyte. The composition of this mineral may be set down as follows:

$KMgCl_3, 6H_2O = KCl + MgCl_2 + 6H_2O = MgCl_2$ 34.2,
KCl 26.9, H_2O 38.9 = 100.

For our purpose we can prepare an easily-fused artificial carnalite by evaporating to dryness on a water-bath a solution of—

400 grammes of crystallized magnesium chloride.
150 grammes of potassium chloride.
60 grammes of ammonium chloride.

This residue may be placed in a large salt-mouthed bottle for use as required. For an experimental run the iron vessel in which the electrolysis is to be carried on is carefully cleaned on the inside by means of sandpaper, to remove any rust and to produce a bright metallic surface from which the magnesium separates. This iron pot is connected to form the cathode, and is placed in the furnace and the gas lighted. A small piece of charcoal is placed in the pot to prevent oxidation as it heats up. When a faint red glow is seen in the bottom of the iron pot, the artificial carnalite is slowly added, allowing each addition to fuse and run before the next portion is added. The pot may in this way be nearly filled, when the carbon anode is put in position through the top. Now, as magnesium is a very light metal and often rises to the top of the electrolyte after being isolated, when it takes fire and is destroyed, it is necessary to protect it. For this purpose a tight-fitting top is the best precaution, fitted with asbestos plugs through which hard-glass tubes pass as indicated in the drawing. By means of these tubes a gas can be passed which displaces the oxygen present, and prevents the combustion of the magnesium. The present writer has connected these glass intake tubes direct to the city lighting gas supply with much success, allowing the coal gas and chlorine to be led away to a hood. In this way we have the magnesium completely isolated from possibilities of combustion, as we all know as general chemists that coal gas being a mixture of hydrocarbons, etc., does not support combustion. For an experiment, therefore, the top is placed in position after the chlorides have fused to a clear, transparent liquid, and coal gas is passed through space over the electrolyte when the electrical current is started. The magnesium isolates smoothly, and may be ladled out and cast into molds, care being taken to allow the electrolyte to cool down considerably before exposing to the air, as it is very likely at high temperature to take fire and burn with a fierce and dazzling light. Of course, for a full efficiency determination of such a process an accurate gas meter, with the necessary observations for gas temperature and atmospheric pressure, should go in with the burner. For a complete physical and electrical study of the isolation of magnesium, the heat value of the fuel gas per cubic foot should be determined by means of a suitable calorimeter. There are several calorimeters especially designed to determine the heating value of gaseous fuels. With our copper voltameter and reliable voltmeter we will be in possession of the essential data for interesting figures taken in connection with the weight of metal produced. This experiment is capable of going still further, using the liberated chlorine, for example, to prepare chloride of lime. For this purpose we should prepare a lead box with lead shelves, upon which we can lay out a quantity of moist slaked lime. The temperature is not allowed to rise above about 25 deg., which is controlled by diluting the chlorine passing into the chamber with air. The constitution of chloride of lime is not known with certainty, but the action between the chlorine and the moist slaked lime is believed to be as follows:

$$Ca(OH)_2 + Cl_2 = CaCl(OCl) + H_2O.$$

Thus a very pretty by-product may be obtained at the time of isolating the metallic magnesium. Let us take a case of a non-igneous electrolyte, and calculate the minimum voltage required. Of these cases we are almost unlimited in a selection, and for this reason a novel case of electrolysis as conducted by the author, to show that sulphuric acid consists of hydrogen, oxygen, and sulphur, may be of special interest. This is an interesting lecture experiment for both beginners in general chemistry and for those advanced in physical chemistry as well. It is believed that the following electrolysis is not generally known, and is published here, as far as the present writer is aware, for the first time. We all know that dilute sulphuric acid electrolyzes into hydrogen and oxygen gases, and that these gases are liberated in the proportion of two volumes of hydrogen to one volume of oxygen. The writer has conducted numerous experiments with concentrated sulphuric acid, and by the proper adjustment of concentration, current density, temperature, etc., has been able to electrolyze the acid into hydrogen, oxygen, ozone, and free sulphur, and at elevated temperatures into hydrogen, oxygen, sulphur trioxide, and ozone. Fig. 2 illustrates the apparatus for conducting such electrolysis. At the left we have a bell jar covering the beaker containing the strongest chemically-pure sulphuric acid over a dehydrating agent, such as calcium chloride. A thermometer is fitted through the stopper as shown, and the electrical connections include electrical instruments for observing the energy conditions. The motor-generator is shown at the extreme right

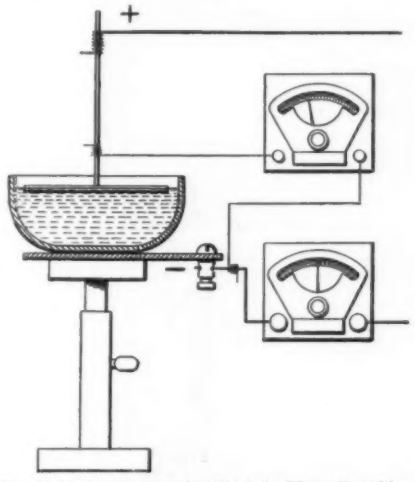


Fig. 3.—Method of Separating Metals by Electro-Deposition Through Adjustment of Electrode Tension.

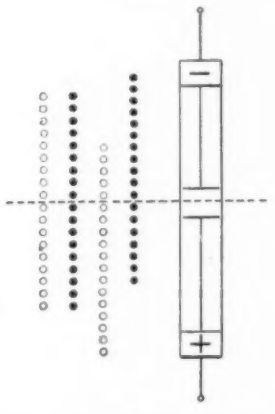


Fig. 7.—Diagram Representing Hittorf's "Transport Numbers." From Hittorf's Researches the Relative Velocities of Ions Are Determined Experimentally, by Concentration Changes.

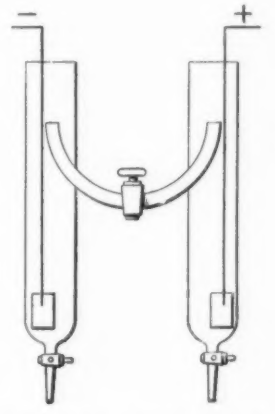


Fig. 8.—Approved Apparatus of Mather and Jones for Experimentally Determining the Relative Velocities of Ions Based upon Concentration Changes.

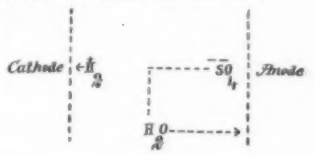
with the controlling rheostats, although the lamp bank serves equally well, if not better, for this particular experiment. Upon passing a sufficiently heavy current through the concentrated acid we get free sulphur at the anode, together with ozone, oxygen, and hydrogen, as indicated in the accompanying equation:

$$H_2SO_4 = H_2 + O + O_3 + S.$$

The sulphur deposits upon the anode and may be burned with its characteristic blue flame before a class to show its presence. The ozone may be detected by moistening a piece of filter paper in starch and potassium iodide preparation, and holding it near the anode during electrolysis. The hydrogen may be collected and burned. The minimum voltage for conducting such an experiment may be calculated by means of our formula to a fair degree of precision. As we are now in a position to follow theoretically as well as practically an electrochemical process, the writer introduces what he believes to be the "mechanism" of this particular electrolysis. In all our practical work we must endeavor to account theoretically for the phenomena involved in practice, for it is the man with the insight into both theory and practice who makes the best investigator. Having calculated the minimum voltage and energy required, and conducted an actual electrolysis, we should certainly endeavor to express what takes place in some concise and scientific manner. In the almost classic case of sulphuric acid and water, the acid is believed to dissociate into the ions

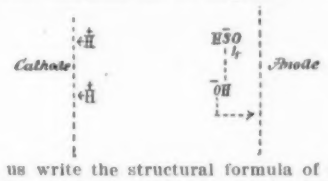
$$\overset{+}{H_2} \text{ and } \overset{=}{SO_4}.$$

The $\overset{=}{SO_4}$ instead of being set free, decomposes the water present, as indicated as follows:



The $\overset{=}{SO_4}$ instead of being set free, decomposes the water present, taking up the two atoms of hydrogen present to form sulphuric acid and liberating oxygen. As the result of certain research work upon the concentrated acid, it is believed to dissociate into the ions $\overset{+}{H}$ and $\overset{-}{HSO_4}$.

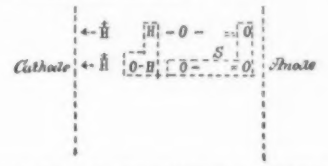
Now, according to recent research upon the conductivity of pure water, water itself is found to be slightly dissociated (about one molecule in a million being broken down thus—$\overset{+}{H}$ $\overset{-}{OH}$) and taking this fact into account, we may have upon this basis the liberation of two volumes of hydrogen and one volume of oxygen equally well accounted for in diagram.



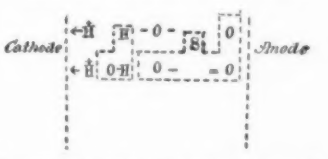
Now let us write the structural formula of sulphuric acid, and endeavor to represent the "mechanism" of electrolysis when we obtain hydrogen, oxygen, ozone, and free sulphur.

$$\begin{matrix}H-O-S=O\\H-O-\quad=O\end{matrix}$$

Here we have the sulphur acting with the valence of six, and a scheme indicating the linking of the acid. How can it electrolyze and give such products? The following diagram shows the probable manner taking dissociated water into account.



Here we also have the formation of a molecule of water within the electrolyte. If the temperature is allowed to rise above 105 deg. C. we obtain hydrogen, oxygen, and sulphur trioxide, with the formation of a molecule of water within the electrolyte as follows:



So much for this side of electrolysis and the part played by minimum voltage, or electrode tension as a factor in experimental as well as in commercial work.

Electrolytic Separation of Metals.

Under the present heading we will take up the art of electro-analysis, and separate one metal from another when they both exist in one solution, through the proper adjustment of electrode tension. Fig. 3 shows a plan for accomplishing this. Here we have a platinum dish resting upon a platinum plate, connected with the negative wire of a storage battery and variable rheostat. A disk of platinum welded to a platinum wire is suspended in the dish to serve as anode, and is connected in turn with the battery. A delicate ammeter and voltmeter complete the equipment, and are joined up as shown. Only instruments of delicacy and precision are applicable for this class of work, and a rheostat capable of fine graduations is absolutely essential. The cells of battery must be so arranged that one or more may be joined in series in a convenient manner. Having set up the apparatus, we are in a position to undertake some experimental work. Fig. 4 illustrates a practical working equipment for separating one metal from another on the basis of electrode tension. A platinum dish and platinum strip acting as cathode and anode respectively are shown in the center. Readers of electrochemical literature will come across the term "polarization" and "polarization current," etc., which refer to the back electromotive force or tension necessary in order to force a current through an electrolyte. Therefore polarization may be understood to refer to the minimum voltage necessary to effect an electrolysis. Le Blanc made many careful researches upon the electrode tensions necessary to decompose various salts, acids, and bases when in solution, and it may be easily seen that we may separate one constituent from another in an electrolyte by carefully adjusting the electrode tension to fall between the two different values for the

different electrolytes. Le Blanc determined the following values for normal solutions:

	Volts.		Volts.
$ZnSO_4$	2.35	$Cd(NO_3)_2$	1.98
$ZnBr_2$	1.80	$CdSO_4$	2.03
$NiSO_4$	2.09	$CdCl_2$	1.88
$NiCl_2$	1.85	$CoSO_4$	1.92
$Pb(NO_3)_2$	1.52	$CoCl_2$	1.78
$AgNO_3$	0.70	H_2SO_4	1.67
HNO_3	1.09	HCl	1.31
NaOH	1.09	KOH	1.67
NH_4OH	1.74	HBr	1.91

This is of course only a partial list, but will be sufficient to serve as a useful guide in the laboratory. Any attempt to outline methods of electro-analysis would be incomplete at this time without introducing the attractive and useful device known as the rotating anode. Suppose, for example, it is wished to determine copper in the electrolytic way, that is by deposition upon a platinum dish. According to the old scheme, we had the dish and a stationary anode. With this arrangement it was necessary to work with a feeble current, or else the deposit of copper would come down dark and non-adherent. For this reason it took many hours, very often, to produce complete precipitation. With the rotating anode, the current strength can be enormously increased, and yet obtain a beautiful pink adherent deposit of copper in a correspondingly shorter time. Here we have an electric motor properly wound to run on a storage battery circuit, *or else especially wound to run on the electric lighting circuit with lamps in parallel. Do not try to use a very small motor.* Procure one several sizes larger than is really necessary to revolve the anode, for it can be much more easily controlled through the agency of our lamp bank, or a special short bank as illustrated at the extreme right in Fig. 5. Here the addition of one lamp will give the motor a certain speed, which may be increased by the addition of others. From thirty to one hundred and twenty revolutions per minute have been found to be excellent speeds, although higher speeds may be used with advantage so long as there is no danger of losing electrolyte by spinning out of the dish. A large disk just above the platinum dish should be included in the equipment, to prevent anything from falling into the dish from the commutator and contact brushes above. The rest of the make-up is so simple, that the illustration should serve to make it clear. A few words concerning the principle upon which the rotating anode accomplishes its rapid precipitation should be given here. The main thing accomplished by the rotating anode is to keep the solution homogeneous in character. Let us take the case of a solution of copper sulphate. If a comparatively feeble current of electricity be passed through an electrolyte consisting of copper sulphate for a long time, there are concentration changes set up. If we use copper electrodes the anode loses in weight just as much as the cathode gains, and there is at all times in the solution the same amount of copper, or to put it in other words, there is always the same number of copper ions in solution. Now, even with the use of copper electrodes and a constant number of copper ions present in the solution, concentration changes will be set up if the current is allowed to flow for any considerable length of time. In such an experiment it is found with copper sulphate, for example, that we get an increase of concentration at the anode and a decrease in concentration at the cathode. Fig. 6 represents the condition of affairs in a vertical glass tube containing copper electrodes and an electrolyte of copper sulphate. The shaded portion represents the concentration of the solutiof about the anode. Now, if this took place, as it does with a platinum dish and stationary anode, the copper ions become so few, or in other words the electrolyte becomes so poor in copper about the cathode dish, that we are held down to the use of a feeble current or there will be trouble in getting an adherent, pink deposition, so necessary for all accurate determinations of copper by electro-deposition. How can these concentration changes be overcome? The rotating anode accomplishes this perfectly, and enables us to keep a constant supply of copper ions about the cathode dish, and allows consequently of a heavy current being employed. How can we explain the concentration changes? Fig. 7 shows by diagram how such accumulation of copper ions about the anode is accounted for according to Hittorf.' The changes in concentration calculated from one of Hittorf's researches are shown in this diagram. Here the white circles represent the anions and the black circles the cathions, and the dotted horizontal line indicates merely the middle of the solution in the vertical containing vessel. The electrolyte is perfectly homogeneous before the electric current is passed, as is seen by an equal number of anions and cathions respectively on each side of the line. In the figure we have nine upon each side. Now allow the current to pass for a given time. We know that different ions have different velocities, and consequently the Cu ions will move in one direction at a different rate from the SO_4 ions in the other direction. It is very often confusing to the student to understand how we can have such concentration due to different velocities of the ions when we have the same equivalence of ions liberated at anode and cathode respectively. No cathion can separate at the cathode until an anion separates at the anode, and for each and every ion which is liberated at one electrode there must be a corresponding ion liberated at the other. There may of course be the case where we have one divalent ion separating at one pole, and consequently two univalent ions separating at the other. Faraday's law teaches us this. As a result of the different velocities, while we have an anion liberated for every cathion, we may have a banking up of the swifter kind of ions, so to speak, ready to discharge. This is illustrated in the little diagram at the right, where we have thirteen anions across the dotted line and only eleven cathions across the dividing line in the opposite direction. Such concentrations may be practically shown by experiment with a piece of apparatus as illustrated in Fig. 8, as devised by Mather, working with Jones. Here a copper sulphate solution, for example, may be electrolyzed, and the solution drawn off from the two tubes respectively and analyzed for concentration. Knowing the original concentration of the homogeneous electrolyte, the number of coulombs passed, and the respective concentrations of the respective anode and cathode tubes, we have all the data for determining the relative velocities of the two ions. This is a very practical piece of apparatus, and with it very interesting concentration changes may be studied.

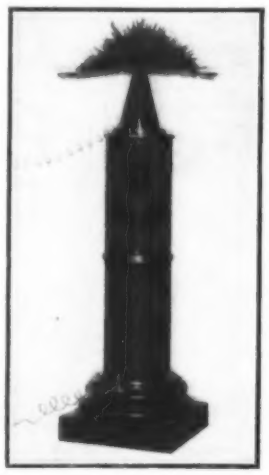
(To be continued.)

THE CONSTRUCTION OF A LARGE ELECTRO-MAGNET FOR OPTICAL AND SURGICAL WORK.

By CLARENCE STERLING.

ABOUT a year ago the writer, at the request of Dr. F. M. Wilson, an oculist of note, set about to design and construct a magnet for the use of this gentleman at the Bridgeport, Conn., hospital. As an extremely powerful magnet of this kind had never been constructed before, considerable difficulty was met with in getting data upon which to base its design. After corresponding with professors of physics and electricity in several leading universities and obtaining all possible information and suggestions, the writer designed and started the construction of the magnet shown herewith.

The magnet is built up around a vertical soft iron core 4 feet high and 6 inches in diameter. The core is bolted to an oak base, and it is tapered on top so as to allow the oculist to examine the patient's eye with



OPTICAL ELECTRO-MAGNET WITH LINES OF FORCE SHOWN BY IRON FILINGS.

an opthalmoscope. The point on top of the core can be unscrewed and removed for sterilizing. On this point is a brass piece carrying a small brass ring for the patient to rest his face on, and which is of the proper height to bring the eye-lashes against the point of the removable cone. While the length of the core may seem excessive, it was considered advisable to make some compromise from theory for the convenient use of the magnet. The coils of wire, which, for convenience of handling, were wound on two brass spools, are of number 7 B. & S. gage, and they weigh 235 pounds.

The wire is insulated with cartridge paper instead of the usual cotton thread. The paper is 5-16 of an inch wide and was spirally wound on the wire by a special winding machine. The surface of the covered wire is very smooth, the edges of the paper coming into close contact, as they were burnished down when passing out of the winding machine. So firmly is the paper attached to the wire that it is not torn when the wire is bent at a sharp angle. The wire was wound on the spools in the following manner, which, while not original with the author, is but little known. The advantages are so great it deserves to be more used. An insulating diaphragm the diameter of the completed coil was placed in the middle of the spool. The wire for this spool was cut in two. About a foot of the wire was passed through the diaphragm close to the core and the rest of this portion was wound right-handed on half of the spool. This brought one end of the wire to the outside, the other end being at the core. One end of the other half was silver-soldered to the end lying on the core and the unfilled section of the spool was filled with this portion of the wire wound on left-handed. By this device the other end was also outside, thus avoiding bringing up the end from the bottom and passing near the various layers of wire. Possible short circuits are thus avoided and a good mechanical appearance is given to the construction. Having decided upon the amount of amperage, the voltage being that used in lighting the hospital, the diameter of the wire was taken from tables of safe carrying capacity and its resistance gave the number of feet required. The diameter of the spool was computed from the following formula:

a = thickness of coils.
b = length of coils.
c = diameter of bottom of coils.
g = diameter of wire and its insulation.
$\frac{b}{g}$ = number of turns of each layer of wire.

As g is contained as many times in a as there are layers of wire, we have the total number of turns, t.

$$t = \frac{b}{g} \times \frac{a}{g} = \frac{ab}{g^2}$$

The length of a single turn of wire on the first layer $= 2\pi \frac{c+g}{2}$; and, for the outside layer, $2\pi \frac{c+2a-g}{2}$

The total length of these layers is represented by

$$\frac{b}{g} 2\pi \frac{c+g}{2} \quad \frac{b}{g} 2\pi \frac{c+2a-g}{2}$$

The intermediate layers form with these two layers an arithmetical progression of which the above expressions are extreme terms and the number of terms is $\frac{a}{g}$. The sum of this series or length of wire is given by

$$H = \frac{b}{g} \frac{2\pi(c+g+2a-g)}{4} \frac{a}{g} = \frac{\pi b a (a+c)}{g^2}$$

The accuracy of these formulæ was shown in that when the winding was completed, one spool had 8 inches too much wire, the other spool not quite a foot. A very slight alteration in straining the wire would account for this. In winding a special device was constructed, as it would not do to have the wire slip with its paper covering; so the slippage was taken up by a coil of rope and this slippage was under control by a weighted lever.

With a potential of 110 volts and 30 amperes the iron core is practically saturated.

A complete saturation is not essential for the oculist. The temperature of the coil after an hour's duration of current was only 123 deg. F., which is well within the requirements of the underwriters.

THE DEVELOPMENT OF A TREE.

FROM the very earliest periods plants have been arranged in three divisions, called respectively herbs, shrubs, and trees. A tree is most highly developed form which vegetable life assumes, and one cannot fail to be impressed by the majestic appearance of a tree that has perhaps stood for centuries, and with its far-extended branches has increased to massive proportions. One thinks of the small beginning of this noble structure. Once this great tree was so small as to be inclosed within a little seed, while now it is made up of many tons of solid timber.

In a previous lesson we traced the early growth of seeds, and we saw that when placed in a suitable soil they begin to germinate under the influence of the warm weather and the moist earth. We learned that the tough covering which affords protection in this early stage was ruptured by the growth of the embryo or infant plant. We saw how the tiny rootlet was sent downward into the earth, while the young stem to which is attached the first pair of leaves grew upward to seek the light and air. These first leaves, in most cases, we found were but temporary structures, and we noted that they perform a distinct and separate duty in the early life of the plant. In them is contained a store of food material elaborated by the plant which produced the seed, and on this store of food we found the young root and stem to be wholly parasitic until they had developed sufficiently to draw sustenance for themselves from the earth and atmosphere.

A study of the very early life of the young seedling cannot but be of unfailing interest, but now we would rather that the student should take the young stem of some dicotyledonous tree in a very early stage, or the stem of some herbaceous plant, and study the primary arrangement of its tissues. A transverse section of any young stem shows on the outside an epidermis which, examined in surface section, is seen to consist of a sheet of cells with cuticularized external walls. Lying beneath the epidermis is a varying amount of parenchymatous tissue, somewhat loosely packed, which is known as the cortex, while the whole of the center of the young stem is taken up by a mass of similar parenchymatous tissue known as the pith.

Between the cortex and the pith, embedded in the ground tissue, there is to be found a ring of well-marked bundles or strands, separated from one another by a portion of the ground tissue, and these bundles run longitudinally up the stem for a considerable distance and then finally bend out into leaf. At the point where this bending takes place another bundle arises and runs upward as before.

These strands, or vascular bundles, are differentiated into xylem or wood, lying next the pith, and phloem or bast, lying next the cortex; but the differentiation does not extend through the bundle, a narrow layer of active tissue being left between the bast and wood, this layer being the all-important cambium.

Next we must consider the structure of a somewhat older woody stem in which secondary growth has taken place, that is to say, new tissue has been formed owing to the activity of the cambium layer and a large increase in size has consequently taken place. From the trunk or from the branch of any dicotyledonous tree it is easy to separate the external layers, known com-

monly as the bark, from the solid wood. Hence we have two very distinct systems to study.

Examine first the smoothed section of a tree trunk that has been sawn off transversely. Probably there will be but little trace of the central pith, while we find the hard solid wood is built up of a number of concentric and almost circular layers ensheathing one another about a common center. In countries such as ours, where the season of growth has only a limited duration, and each winter there is a period of cold and vegetable inactivity, the age of the tree can be approximately ascertained by counting the number of rings or circular layers of wood in a cross section of its stem, since each year there is formed in the spring a new layer of wood. In our transverse section of the tree trunk we also find a number of lines which radiate from the center to the circumference of the stem, and partition the wood off into a number of wedges; these lines are known as the medullary rays, and they are of great service to the tree, as they stretch from the center of the wood to the bark, and by their means an exchange of sap is maintained between these two parts.

As each year a new layer of wood is deposited on the exterior surface of last year's growth, a steady increase in the thickness of the stem is brought about, and hence the ring of epidermis, which, in the first year of the tree's life, consisted of flat tabular cells packed closely together, is subjected to a gradual but incessant distension, and is finally fissured and rent. To replace this ruptured tissue there is a continual formation of new layers of bark which are deposited on the interior surface of the ring of bark of the previous year. These layers become suberized, and are rendered impervious to the passage of water or gases, hence all the cells and tissues outside the active forming cork cambium soon die. Usually the bark bears but a small proportion in thickness to the wood, since the annual development of the wood rings prevents an accumulation of bark to any extent; but in the cork oak, whence we derive all our supplies for commercial use, the bark grows to a very considerable thickness, and can be taken off in thick sheets as often as every eight or ten years.

The rings of wood when fully developed consist of three elements: the fiber cells, the vessels or duct cells, and wood parenchyma cells, or what may be looked upon as merely packing tissue. The wood fibers form a large proportion of all ligneous deposits. They are attenuated cells, whose length greatly exceeds their other dimensions, and they lie together in bundles with their pointed ends overlapping or extending in between the ends of their immediate neighbors. Their vital activity only continues for a short time. At first the sap flows through them, but soon the walls become thickened with a deposit which goes on accumulating until their cavities are finally closed, sap no longer passes through, and their function is but the mechanical one of affording support for the tree.

The vessels which comprise the duct tissue originate out of a row of cells, whose separating cross walls have been absorbed so that a long continuous tube is formed. These vessels are marked in various ways and are known to botanists as spiral, annular, scalariform, etc., according to their particular markings, but in each case their function is the same, that is they serve as carriers of air and fluids, and it is through them that the sap circulates from the rootlets up the stem and into the ultimate veins of the leaves. Attention was drawn above to the fact that there was deposited in the fiber cells a large amount of some sort of secretion which sometimes is colored, and hence a change in the color of wood is often very marked. In a transverse section of the stem of the guaiacum tree or the cherry tree, which is perhaps a more familiar study, a very striking difference is apparent between the circular beds of wood toward the interior of the stem and those situated nearest the bark. The former are of a deeper color and are more compact than the latter, which are, on the contrary, pale, and of a looser texture. The pale wood nearest the bark is called the alburnum or sap-wood, as the sap still continues to circulate there to a greater or less extent, while the older, more compact, deeply colored and more solidified wood which occupies the more interior part of the stem is called duramen, or heart-wood, and consists of dead cells, the cavities of which have been filled up with secreted matter. It is this part which is valued by the cabinet maker as being most suitable for his purpose.

Mentioned above is the fact that from a dicotyledonous tree trunk there can always be easily stripped from the solid woody stem a layer popularly known as "the bark." This layer, which separates thus from the wood at the cambium ring is, however, not the "true bark" of botanists. Bark, in the strictest botanical application of the term, consists of all dead tissue (cork) lying outside an active forming cork cambium, which may be situated in any part of the cortex, while bark, as popularly known, consists of all tissues lying outside the cambium ring, which is constantly forming new wood and new bast, and hence is made up of the bast, the cortex, and as much cork as may be formed. The bast or phloem is made up principally of sieve tissue with a little parenchyma. This sieve tissue or soft bast, down which the sap descends after it has been elaborated in the leaves, consists of sieve tubes, long slender structures composed of elongated cells placed end on end, and they derive their name from the fact that their end walls are perforated by a number of apertures through which the contents of the two segments communicate. These sieve plates are covered on both surfaces by a peculiar substance called "callus," and this in the autumn is often developed to such an extent that the pores are completely blocked up.—The Pharmaceutical Journal.

Correspondence.

WHY DOES A CHAMELEON'S COLOR CHANGE?

To the Editor of SCIENTIFIC AMERICAN:

Noting the question, "Why does a chameleon change color in moving from one plant or object to another?" I wish to give the result of my investigations on the subject from a scientific standpoint in harmony with Lord Kelvin's statement that "matter apart from electricity does not nor cannot exist." Also the further deduction that color, heat, and light are but different forms of electricity. I had in my possession for six months a chameleon, the phenomena of whose life and movements I carefully noted each day. I received the animal from a nephew who had it in possession for some five or six weeks. He had it chained to the cover on a table that stood in his room in a city boarding house. He never gave it food of any kind. I asked him what it ate. He replied: "I suppose flies, as there were always plenty within range." He had never given it water. When I received it, I kept it on small branches of some trees freshly cut every day. When, during the latter part of September, the frost had destroyed the green leaves, I noticed the chameleon began to grow very awkward in its movements, as though his limbs were stiff from old age. One morning he was quite unable to move and was of a reddish-brown color, just about the color of brown oxide of gold. Some two or three weeks previous the skin from the top of the head became loose and I removed it and have it in possession yet. It is iridescent, the colors of the opal being easily visible. The color becomes pale violet when held in an oblique line with the sun's rays. I then became much interested in watching the new growth on the head. There appeared a circular growth of something that looked like mercury, and when viewed through the microscope, the mercurial spots looked as though they would drop from the skin. Wherever the animal was of a reddish-brown color, these spots would become copper color. When the chameleon became so stiff that it could not move, I was much afraid it would die, so I went in search of some fresh leaves and obtained some green catnip in a sheltered corner. I placed the stiffened form on the leaves, and in two minutes it had regained its green color and was as lively as it had ever been. I then offered it water, which it drank quite greedily. Every morning afterward I gave it a drink. It would only drink once a day. The water appeared to take the place of green leaves. During at least four months the animal did not receive any food whatever except the emanations of gas from the leaves. During its six weeks' existence under my nephew's care it did not have the green leaves from which to receive nourishment. It must have received through the property the skin possesses of changing color by the absorption of gaseous emanations, the food necessary for its continuance of life. When placed on colored cotton it changed color much quicker than when placed on wool or silk, the cotton no doubt parting with color more readily than does either wool or silk. The red color was only noticeable along the backbone and certain other centers of muscular tension. After the equinoctial storms had passed (I was watching for effects about this time) it again became reddish-brown and the top of the head became quite spotted with gold-like spots where the mercurial spots had been. One evening a young lady took the chameleon in her hand, and we both were looking at the gold spots on the head, when there was projected from these spots a shower of tiny gold specks that covered the fingers of the hand holding the animal. We watched these sparkling particles for twenty minutes to see if they would vanish but they seemed fixed in their formations. When viewed through the microscope, they appeared as particles of gold. After shedding this substance the animal was quite lively in its movements for some days. During the first week of October, the young lady above mentioned placed the chameleon on her blouse and went out one afternoon to visit some friends. Whether the emanations or rays from her body were too intense for the animal, or whatever phenomena took place, she said it became of an unusual size and finally seemed to burst, as it died and appeared like a wrinkled piece of paper. My impression is this: The chameleon changes its skin or its skin is changed on the same principle that changes the colors produced by bacteria. The bacillus pyocaneus produces a greenish fluorescent color which crystallizes in long, blue needles. When treated with an alkali the blue becomes red, when by an acid it becomes yellow. This bacillus, when given certain conditions of growth, produces a brownish-yellow basic color which assumes a fluorescent green color when in contact with oxygen, or a bluish green, or reddish blue, just as the conditions of growth are modified. In certain animals color is a sort of permanent magnet for the attraction of certain light radiations and the chameleon appears to possess in its skin a formation so equally balanced between an alkali and an acid that either body will cause a change of color in harmony with its own composition or color. The chameleon is a cold-blooded animal, so that temperatures would not destroy the effect of color. The bacillus pyocaneus represents a system of color magnetism that reaches its perfect development in the gorgeous plumage of the peacock. Color is a "magnet" as much as any steel magnet known to-day. C. E. HUMBERSTONE.

Newton Brook, Ont., Canada, January 23, 1905.

ENGINEERING NOTES.

A favorable report has been issued on the possibility of piercing the Alps, by a railway connecting the Bernese Oberland and the Simplon, without, as do the present day trains from Berne to the Rhone Valley, running westward to touch lines bordering the Lake of Geneva. It would connect Berne with Brigue in the Rhone Valley—the Swiss terminus of the tunnel—by a total route of 72½ miles, running south through the Blumenstein and Wildstrübel mountains to the Rhone, and then turning east through the canton of Valais to Brigue. The greatest elevation reached would be 1,128 meters. The region supplies abundant water-power for electrical working.

A method of determining the moisture in steam at atmospheric pressure was described by Prof. D. S. Jacobus, of Stevens Institute, in a recent paper read before the American Association for the Advancement of Science. A known weight of superheated steam at a given temperature was mingled with a known weight of saturated steam at atmospheric pressure. The steam, after the mixture, was still superheated and its temperature was measured. Careful measurements were made to determine the radiation of the apparatus. From data thus obtained the amount of moisture in the saturated steam was determined. This method, he explained, is similar to that employed by Mr. George H. Barrus in one of the older forms of his calorimeters. The particular problem to be investigated was how much moisture would be contained in steam at atmospheric pressure after it had passed through two separators of a certain form. The tests showed that the steam at atmospheric pressure leaving the separators contained about one-tenth of one per cent of moisture, a result which was within the probable error of the instrument, for which reason it was fair to conclude that the steam was dry.—Eng. Record.

The production of the Baldwin Locomotive Works, Philadelphia, Pa., for 1904 was 1,453 locomotives, of which 1,352 were actuated by steam, 94 by electricity and 7 by compressed air. This is a reduction of nearly one-third from the number built in 1903, which was 2,022. The locomotives exported aggregated 286, to the following countries: Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Guatemala, Hawaii, Japan, Korea, Mexico, Zealand, Peru, Porto Rico, and South Africa. The company reports a very much better condition of affairs for the coming year. Up to this time orders have been booked for a total of 350 locomotives for the Pennsylvania Railroad Company. These are both of the freight and passenger type, and are apportioned into 325 locomotives for the lines east of Pittsburg and 25 for lines west of that city. The Missouri Pacific Railroad has placed an order for 50 locomotives, and the Cincinnati, Hamilton & Dayton an order for 30. A large number of orders have been booked for smaller quantities, both from railroads and individual concerns. The prospect for future business is very good; preparations are being made to operate the plant on a much more extensive scale than was the case during the last half of the past year.

It is now a good many years since Mr. Druitt Halpin proposed a system of thermal storage for rendering available for power purposes steam produced at times when it could not be immediately utilized. The proposal, as made, had special reference to reducing the boiler capacity needed to carry the load on an electrical station at the time of maximum demand. The principle is, however, available in other circumstances, and in a paper read before the West of Scotland Iron and Steel Institute Mr. P. J. Mitchell described the plant by which Prof. Rateau has rendered available the very large quantities of exhaust steam now wasted at large colleries and iron works. It should be noted that it is more economical to use this steam in a turbine than it is to merely fit the engines with a condenser, since, when it comes to dealing with steam at low pressures, the very best reciprocating engine is easily distanced by even an inefficient turbine. The difficulty to be met lies, however, in the fact that at rolling mills and steel works the supply of exhaust steam is very fluctuating; and though the waste may represent 1,500 horse-power or more, some method of thermal storage is essential if this is to be commercially available, as the demand for power is a constant and not a fluctuating one, or, at least, such fluctuations as exist cannot be expected to synchronize with those in the supply of exhaust steam. Three patterns of "thermal stores" or regulators, are used by Prof. Rateau. In the one case the regulator consists of a large vessel filled with cast-iron trays containing water, in which is stored up the surplus energy received at times of large supply of exhaust steam, to be evaporated off again at times when this is deficient, so that a supply which is practically steady is supplied to the turbine. In another pattern the vessel is filled with masses of scrap iron. In both these cases the large quantity of metal present greatly facilitates the rapid interchange of heat. In the third pattern the heat is stored in water as in the Druitt-Halpin system; but to insure a rapid interchange of heat between the steam and the water the exhaust steam is introduced below the surface of the latter, into which it escapes by a series of small orifices so arranged that the water is kept in a state of constant agitation. With a steam supply at 29.4 pounds absolute per square inch, and a vacuum of 25 inches, the consumption in the turbine per electrical horse-power is only 20.1 pounds, while with steam at 14.7 pounds absolute and the same vacuum, it is 26.5 pounds per electrical horse-power hour.

TRADE NOTES AND RECIPES.

Blue Varnish, English, for Oil Cloth.—Boil 180 kilos of good oil linseed oil with 8 kilos of manganous borate and 10 kilos of Paris blue until a drop of the oil "stands," that is, until it no longer spreads; next add 40 kilos of melted kauri copal and as much turpentine oil or benzine as is necessary for the desired consistency.

Constant stirring is imperative, and the temperature must not be carried beyond 300 deg. C., otherwise there will be danger of ignition.

Both the copal varnish and the blue varnish for oil cloth must be allowed to settle for some time or else be filtered through wadding while still warm.—Der Chemisch-Technische Fabrikant.

Liquid Starch Gloss or Ironing Oil.—According to the Apotheker Zeitung, liquid starch gloss is prepared as follows: Pour 250 grammes of water over 5 grammes of powdered gum tragacanth until the powder swells uniformly; then add 750 grammes of boiling water, dissolve 50 grammes of borax in it, and stir 50 grammes of stearine and 50 grammes of talcum into the whole. Of this fluid add ¼ liter to 1 liter of boiled starch, or else the ironing oil is applied by means of sponge on the starched wash, which is then ironed.

Artificial Pumice.—Natural pumice stone is an excellent material for polishing and cleaning, but it is too variable in texture and hardness, even in the same piece, to be perfectly satisfactory. Artificial pumices are made of mixtures of clay and sand, of various composition and degrees of hardness, according to the use to which the mass is to be put. Wax cloth, leather, felt, and wood workers are supplied with either hard or soft compositions of coarse grain, while for polishing purposes either a medium or a fine grain can be had. Like natural pumices, they are used either dry or with oil according to circumstances.—Farben Zeitung.

To Clean Matt Gold.—Take 80 grammes of chloride of lime, and rub it up with gradual addition of water in a porcelain mortar into a thin even paste, which is put into a solution of 80 grammes of bicarbonate of soda and 20 grammes of cooking salt in 3 liters of water. Shake it, and let stand a few days before using. If the preparation is to be kept for any length of time, the bottle should be placed, well corked, in the cellar. For use, lay the tarnished articles in a dish, pour the liquid, which has previously been well shaken up, over them so as to just cover them, and leave them therein for a few days. In very stubborn cases one may dilute somewhat. Next wash the objects, rinse with alcohol, and dry in sawdust.—Metallarbeiter.

Machine Oils.—Users of machinery oil, aware that one of the first things necessary in the oil is that it should be absolutely destitute of free acid, often think they are safe in using crude rape oil. They fear, if they use refined oil, that it will contain some of the sulphuric acid used in purifying it. This fear is not unfounded, but unfortunately the crude oil often contains one-half per cent or more of free oleic acid, which is just as bad for lubricating purposes as sulphuric. The oleic acid roughens the brasses, and creates more friction by forming sticky metallic oleates. Care must be taken that in a lubricant, petroleum, often of much greater advantage, especially for small or very quick-running machinery, is not replaced by resin oil. This oil resinifies in time, and clogs the bearings. Perhaps the best test for an oil is to spread a few drops of it over a clean sheet of copper, and then to observe whether the copper turns green. If free acid is present, it will do so, quickly or slowly, according to whether the amount of acid is large or small. The oil must also take a very long time to dry. The best oil is that which does not alter the natural color of the copper, and which takes the longest time to dry.—Wiener Seifensieder Zeitung.

Liquid Metal Polishes.—

I.

Kieselguhr (infusorial earth)	56 kilos
Paraffine oil	30 liters
Spirit, denaturized	15 liters
Spirit of camphor	5 liters
Turpentine oil	5 liters
Spirit of salammoniac, sp. gr. 0.910.	3.75 liters

II.

Tripoli	9 kilos
Kieselguhr	9 kilos
Japan wax	5 kilos
Oleine	12 liters
Benzine	90 liters

III. Fulmenol.

Neuberg chalk	100 kilos
Oleine	64 kilos
Spirit of salammoniac	38 kilos
Spirit, denaturized	49 kilos
Benzine	49 kilos

IV. Meyer's Putz Cream.

Oleine, white	10 kilos
Stearine	5 kilos
Kieselguhr, extra white, elutriated	20 kilos
Turpentine oil	20 kilos
Benzine or petroleum (high boiling)	25 kilos
Spirit, 96 per cent	5 kilos
Spirit of salammoniac, 0.960 sp. gr.	6 kilos
Water	5 kilos

All polishing agents may be perfumed with mirbane oil, amylacetate, ordinary lavender oil, or safrol.—Neueste Erfindungen und Erfahrungen.

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TABLE OF CONTENTS.

PAGE

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II. ELECTRICITY.—Contemporary Electrical Science.... 24367
Our Myriads of Telephones and Telegraphs.... 24366
Wireless Telegraphy Experiments at the Eiffel Tower.—By EMILE GUARINI.—4 illustrations.... 24380

III. ELECTRO-CHEMISTRY.—Experimental Electro-chemistry.—VII.—By N. MONROE HOPKINS, M.Sc., Ph.D.—8 illustrations.... 24376

IV. MECHANICAL ENGINEERING.—Practical Data on European Practice with Steam Turbines.—By FRANZ KOESTER.... 24367
Pumps.—By PHILIP R. BJORLING.—6 illustrations.... 24369
The Matitsch Lace-making Machine.—By A. MATITSCH.—3 illustrations.... 24373

V. METEOROLOGY.—Meteorology in the British Empire.—I.—By Sir JOHN ELIOT, K.C.I.E., M.A., F.R.S.... 24373

VI. MINING AND METALLURGY.—Ore-concentration Plant at the St. Louis Exhibition.—1 illustration.... 24369

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PAGE
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..... 24367
..... 24369
illus-
..... 24372
—By
..... 24373
nt at
..... 24368